Latin as the Language of Science and Learning

Roelli, Philipp

Abstract: This book investigates the role of the Latin language as a vehicle for science and learning from several angles. First, the question what was understood as 'science' through time and how it is named in different languages, especially the Classical ones, is approached. Criteria for what did pass as scientific are found that point to 'science' as a kind of Greek Denkstil based on pattern-finding and their unbiased checking. In a second part, a brief diachronic panorama introduces schools of thought and authors who wrote in Latin from antiquity to the present. Latin's heydays in this function are clearly the time between the twelfth and eighteenth centuries. Some niches where it was used longer are examined and reasons sought why Latin finally lost this lead-role. A third part seeks to define the peculiar characteristics of scientific Latin using corpus linguistic approaches. As a result, several types of scientific writing can be identified. The question of how to transfer science from one linguistic medium to another is never far: Latin inherited this role from Greek and is in turn the ancestor of science done in the modern vernaculars. At the end of the study, the importance of Latin science for modern science in English becomes evident.

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Latin as the Language of Science and Learning

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Part 2 **Diachronic panorama of Latin science and learning**

Acknowledgements and practicalities

This book took a long time to come to fruition. Back in 2010, I started to contemplate the idea of studying the relationship between Latin and science, especially linguistically, a topic that had previously hardly been tackled at all. Over time I realised that such linguistic study cannot meaningfully be done without first studying the changing approaches to what science is during the long cultural dominance of Latin in Western Europe. This led to the first two parts of this book. At the time, there were no open tools for corpus linguistic studies of serious amounts of Latin text in existence, which is why I started the Corpus Corporum project (http://www.mlat.uzh.ch) in 2012 – an open full-text Latin repository able to process texts in the standard TEI xml format. It automatically lemmatises every Latin word and adds grammatical information such as parts of speech to it. A COST grant (IS1005) enabled me to initiate the project, and I thank the Chair of Mediaeval Latin in Zurich for supporting the ongoing running costs of Corpus Corporum. Its software was initially developed by Max Bänziger and is now being developed further by Jan Ctibor (University of Prague); the project is ongoing and by now collaborating with many other scholarly institutions. It has grown into the largest Latin text repository in existence, with more than 8,500 texts and 165 million words. Corpus Corporum provided much of the input data used in this book, especially in part 3.

During this long time, I have studied, learned, taught, and worked at the Seminar for Mediaeval Latin of the University of Zurich (since 2014 part of the Department for Greek and Latin Philology). My warm thanks are due to these institutions and especially to my late teacher Peter Stotz, who read an early version of the book and suggested improvements, and to the current Chair of Mediaeval Latin, Carmen Cardelle de Hartmann; they both provided me with the ideal environment for such long-term in-depth studies – something that is becoming increasingly rare in today's fast-paced university environment. This study was accepted as a habilitation thesis in Latin philology in 2021 at the University of Zurich. Further thanks are due to the reviewers – Martin Korenjak (Innsbruck) and a further anonymous reviewer of the habilitation commission – as well as to the commission itself, consisting of Carmen Cardelle de Hartmann, Ulrich Eigler, Philipp Sarasin, and Paul Widmer. The importance of institute research libraries where relevant literature about authors and works can be found together in one place – an institutional structure now regrettably to be abolished in Zurich – for writing a book like the present one can hardly be emphasised too much. I profited greatly from the existence of the Mediaeval Latin and classics libraries at the University of Zurich. There is still a long way to go before a fully digital world of scholarship might be able to provide similar aids in these fields. I have also re-

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ceived important feedback on individual chapters or topics from my Zurich colleagues José Luis Alonso (Roman law), Wolfgang Behr (Chinese), Benjamin Gleede, and Emanuele Rovati (Arabic); from Fabio Acerbi of the CNRS Paris (Greek mathematics); and at a number of congresses that provided instructive and interesting discussions on a variety of topics related to this book, in Benevento, Uppsala, Greifswald, Vienna, Berlin, Paris, Innsbruck, and Milan. Any remaining mistakes and inadequacies are, of course, entirely my own. Last but not least, I thank the editors of the 'Lingua academica' series, Wolf Peter Klein, Michael Prinz, and Jürgen Schiewe, who kindly accepted this book, as well as the Swiss National Fund for funding open access of the book and thus making it much more widely accessible.

The following abbreviations are used in this book, most of them only in the chapters involving corpus studies (chaps 18–20):

- ABL: ablative case
- ABL ABS: *ablativus absolutus*
- ACC: accusative case
- ADJ: adjective
- ADJ-SUF: adjective suffix (in our analyses: *-alis*/*-aris, -bilis, -eus, -icus, -inus, -ivus, -orius, -osus*)
- ADV: adverb
- avg: average
- CONJ: conjunction
- CONJ:C: coordinating conjunction
- CONJ:S: subordinating conjunction
- DAT: dative case
- ESSE: the verb *esse*
- GEN: genitive case
- IND: indicative mood
- INF: infinitive
- modifier: sentence-modifying particles (in our analyses: *at, autem, enim, ergo, igitur, nam, vero*)
- N: noun, i.e. substantive (not including ADJ and PRON)
- N-SUF: noun suffix (in our analyses: *-tio*/*-sio, -tas, -itia, -ntia, -mentum, -tor*/*-sor, -tudo*)
- NOM: nominative case
- OCR: optical character recognition
- PCA: principal component analysis
- PIE: Proto-Indo-European
- PoS: part(s) of speech
- POSS: possessive pronoun

- PREP: preposition
- PRON: pronoun
- PTC: participle
- REL: relative pronoun
- stdev: standard deviation
- SUB: subjunctive mood
- V: verb

There are many quotations in this book. All that go beyond single words are presented in the original, followed by a literal English translation. Where no translator is identified, translations are my own. As language is the central issue of this study, it seemed important to include the original wording throughout. I have sought to render key Latin terms with a single English word as far as possible, but there is some inevitable variation depending on time, school, subject, and context. It may be appropriate to mention the most central terms of the study here: I have translated *cognitio* as 'cognisance', 'acquaintance', or 'becoming acquainted'; *disciplina* as 'discipline' or 'science' (especially in Antiquity); *doctrina* as 'teaching'; *eruditio* as 'education', 'erudition', or 'learning'; *notitia* as 'knowledge'; and *scientia* as 'science', 'certain knowledge', or 'knowledge'. These and similar key terms are discussed in detail below (chap. 2).

Texts from languages using a non-Latin alphabet (except Greek and Cyrillic) are transliterated according to the standard method for the language in question: Arabic following the conventions of the Deutsche Morgenländische Gesellschaft (DIN 31635), Hebrew following ISO 259, Sanskrit according to the International Alphabet of Sanskrit Transliteration, and Chinese as *pīnyīn* with tone marks; if necessary, Chinese characters in the more generally read simplified script are also included. Modern Greek is spelled monotonically (the form officially in use in Greece since 1982) in order to easily distinguish it from older forms of the language, but using the traditional, more historically accurate καθαρεύουσα orthography. For quotations in the ancient languages, the edition used is identified. Books are denoted by Roman numerals; chapters, paragraphs, and other subdivisions by Arabic ones. If there are two alternative numbering systems, one is included in parentheses, for instance Varro, *De lingua latina* V.1(13). For further details on citation forms, see the bibliographies at the back of the book.

Vosa, Corpus Christi 2021
Philipp Roelli

Introduction

> *[S]aepe enim ad limitem arboris radices sub vicini prodierunt segetem.*
> ‘Often the roots of trees close to the boundary protrude under the neighbour’s field.’
> Varro, *De lingua latina* V.1(13), ed. Goetz & Schoell, p. 7

§1 This study sets out to provide a broad overview of the topic announced in its title, investigating the rôle of the Latin language as a vehicle for science and learning over much of the time of its existence. It will focus especially on the linguistic changes that have occurred in this process. This is a topic that has hardly been tackled either by linguists or by historians of science; the present contribution must remain patchy and will have to omit some important issues and touch on others only lightly. The study of scientific Latin can be likened to a tree that grows close to the boundaries of many fields and extends its roots into them, as expressed in the motto above.

Mostly, this study is one of linguistics, but linguistics applied to the history and theory of science in a way that what is sometimes known as the ‘linguistic turn’[1] in the history of science has failed to do. At a time when theoreticians of science are further from a consensus about what the term ‘science’ is actually supposed to mean than they have been for centuries – with ‘realists’ (who believe that science is approaching the ‘truth’), ‘relativists’ (who believe that science can be distinguished from non-science only by sociological means), and many shades in between – we ought to start our investigation by finding out what the words involved (in Latin most importantly *scientia*, in Greek ἐπιστήμη) have meant during the roughly 2,500 years covered in this book, and to what extent they have constituted concepts that delineated a clearly defined group of activities in these different times and how this relates to present-day understandings of ‘science’. After such a diachronic and diaglossic lexicographical investigation, it will become more feasible to delimit and define science in a way that can make sense through the entire time span considered here. In order to get a grip on these changing conceptions, it will be necessary to start with an analysis of the relevant terms for denoting scientific activities, nearly all of them born in Greek, then transferred to Latin, and in modern times to a great extent adopted by the European vernaculars. All too often, ‘science’ is defined at the outset a priori in order to then check what falls under such a concept and what does not.[2] After having found a tenta-

1 This ‘linguistic turn’ stressed the merely linguistic nature of scientific ‘truth’, thus placing this approach in the ‘relativist’ camp. For a summary of recent developments, see Wootton (2015: 511–555).

2 Some such definitions are discussed in chap. 4 §3 below.

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tive descriptive 'definition' of science applicable to all the periods studied here, we will start to identify prerequisites a sociolinguistic style of language needs to fulfil in order to be a vehicle for it.

The second part of the book provides a chronological panorama of science written in Latin, focusing on the relationship between approaches toward science (the scientific *Denkstil*; see chap. 4 §1) and the types of Latin used. This complements the study of the development of the terminology for science considered largely without such a temporal perspective in part 1. This chronological view also deepens the understanding of the relation between Greek and Latin science gained in part 1. Obviously, the entire time span of the use of Latin as a language of science and learning cannot be treated in great detail; rather, some schools and authors and their Denkstil are presented in the hope of outlining the 'bigger picture'. That picture will depict a largely organic growth of Latin science (with the most important caesura in the twelfth century) that leads from classical Greek science to present-day science. These complicated feedback loops of language, translation, culture, learning, and science are often overlooked in the modern history of science, which often still has a tendency to have 'real' science begin only in early modern times. Our approach will also disregard the still-common strict distinction between 'native-speaker' Latin and 'artificial' Mediaeval and Early Modern Latin. Johann Albert Fabricius (1668–1736) led the way in rightly treating Latin literature and culture as a single, large unity.[3] Within this long time span, it will become clear that Latin's rôle as a language of science and learning was most prominent in the half-millennium between the twelfth and the eighteenth century. The first half of this period is usually termed 'scholastic', while the second introduces what is now considered paradigmatic science, which might be labelled 'mathematics-based empiricism'.[4] The rôle of Latin in this process has hitherto hardly been taken into account. It will be interesting to see to what extent these two phases are reflected in the language used. Another goal of this study is to see what automated digital tools, such as Corpus Corporum,[5] can contribute to our knowledge of linguistic change in Latin. It would seem that they can, indeed, be very helpful, especially when used together with and not instead of traditional philological approaches.

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3 Fabricius, *Bibliotheca,* published 1734–1746. This point of view seems finally to be gaining ground; for example, the important study Leonhardt (2013) shares it. A reader on 'the Latin of science' has recently been published: Epstein & Spivak (2019). On 'dead' languages versus those with native speakers, see chap. 16 §1 below.

4 Taton's (1958–1981) history of science, for example, splits vols 1 and 2 at this watershed (ca. AD 1450).

5 The project is online at http://www.mlat.uzh.ch; details about it can be found in Roelli (2014b).

The linguistic study of language conveying scientific knowledge, or in German *Wissenschaftssprachforschung*, has become quite a popular subject recently, especially for the German and English languages, as can, for instance, be seen from the existence of the ‘Lingua academica’ series itself, but scholarly interest in this field is only about half a century old.[6] For the classical languages this is much less the case at present. Thus, our approach will have to be tentative, looking for suitable approaches; it is hoped that it will stimulate further research, possibly using more appropriate tools. Apparently out of frustration, the linguist Leonard Bloomfield destroyed a three-hundred-page manuscript, ‘The Language of Science’, a century ago.[7]

The present book, then, consists of three parts. In a first part, the semantics of ‘science’ are studied diachronically and diaglossically, especially for Greek and Latin. Second, a panorama of the use of Latin as a language of science and learning is presented, beginning with a brief digression about its Greek background and finishing with some considerations about the demise of Latin in this function and its replacement by the vernacular tongues. Third, linguistic approaches seeking to characterise this scientific Latin more closely and to confront it with other languages of science are applied.

Why ‘language of science’?

> Es zeigt sich, dass die Sprache der Wissenschaft und die in ihr sich bezeugende Auffassung der Dinge, die wir leicht als etwas Selbstverständliches ansehen, unter harten Kämpfen durch die Arbeit von Jahrtausenden ausgebildet ist, dass das Einzelne ganz bestimmten geistigen Strömungen entsprang, das Ganze eine fortwährende Erhebung des Denkens über die unmittelbaren Eindrücke zur Vorbedingung hatte.
> ‘It becomes clear that the language of science and the conception of things it expresses, which we easily take for granted, was formed in hard struggles through the work of millennia, that its particulars originated from very specific intellectual currents, its entirety had as its precondition a constant elevation of thought above immediate sense impressions.’
>
> Eucken (1872: 8–9)

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6 An attempt (possibly the first one) was made by the entomologist (and non-linguist) Savory (1953) for English. Barber (1962) provided the first quantitative linguistic approach for English in this function. Although scientific English is often studied nowadays, this usually happens in order to teach people, especially those whose mother tongue is not English, how to produce it. Examples range from McDonald (1931) to Skern (2011).

7 Langslow (2000a: 3n16), with references to standard works that could be expected to but do not consider technical language.

§2 It is only too easy to overlook Eucken's reminder of one and a half centuries ago, especially in a time when even small national languages have become equipped with a full *instrumentarium* to speak about anything of interest in the modern world. One might, therefore, easily come to think that all thoughts are expressible in all languages, albeit using slightly different grammatical and syntactic means to this end, as, indeed, has sometimes been claimed by a position called 'universal translatability'. A few examples will be given shortly to show that this is by no means the case. The more modest but still mistaken claim that at least all scientific knowledge is universally translatable[8] is also often encountered, and will be discussed below (chap. 14 §7). Languages do tend to be ingenious in translating categories and concepts they lack from other languages when a strong need is felt among speakers and they are given time to perform the task. A central point of this book will be that Latin (and Greek) were crucial in the process that led to the common misconception that translation between the languages of peoples far apart in geography and in *Weltanschauung* is a matter of course. For every pair of languages there will be both words and grammatical structures in the one that cannot be expressed in the other, unless their speakers learn to do so through prolonged contact and through borrowing of words or structures, or by adapting their own linguistic systems internally.[9] As the Latin-speaking world took over its scientific ideas lock, stock, and barrel from the Greek-speaking world,[10] this is precisely the process that Latin had to begin performing in Antiquity – and had still not fully completed a millennium or more later (see chap. 10 §6) – in order to convey Greek scientific thought, and then to subsequently develop it further and transform it into something new. The vernacular tongues had to undertake this very same process in order to become capable today of conveying Greek and Latin ideas with ease.[11] The worldwide success of this Graeco-Latin approach to science and knowledge has produced a *Begriffsgemeinschaft*[12] that makes it only too easy

8 Strangely enough, there is today (especially in the ever more monolingual Anglo-Saxon world) still a feeling that scientific content is especially easy to translate from one language into another; for example, Savory (1953: 113) states that 'scientific prose [...] can be translated into languages other than the language in which it was first written, not merely satisfactorily but perfectly'. The same point is stressed by Gordin (2015b: 11), with examples; but he rightly also points out that 'scientific languages are not born, they are made, and made with a good deal of effort' (29). Only once they have been made compatible does translation between them become easy.

9 For some examples of lack of translatability, especially between Russian and English, see Catford (1967: esp. chap. 14, 'The Limits of Translatability').

10 See chap. 8; for exceptions, see chap. 8 §12.

11 See chap. 23 on how much Greek and Latin still dominate our modern scientific jargons.

12 Betz (1949: 9) spoke aptly of an 'abendländische Begriffsgemeinschaft' ('occidental *Begriffsgemeinschaft*'). Peano (1915) gives a good idea of this common vocabulary (although with a very difto forget that translation, even between highly developed cultures, was not at all easy in the past. Despite today's globalism and *Begriffsgemeinschaft*, in the case of Chinese it is still evident how hard the transfer of ideas between languages can be (see chap. 23). Historical examples, especially that of Greek science being translated into Arabic and Latin, will be a recurring theme in this book.

The privilege of being carriers of leading science and learning has remained confined to very few languages, little more than a dozen in the history of mankind, as it would seem.[13] What makes this difficult process of adopting scientific insights from another language especially fascinating is that it will inevitably slightly alter the content and turn it into something new and different, even against the translators' intentions; this will become plain in the case of Greek science being taken over into Latin. Greek sciences in Antiquity, early modern science in Latin, and contemporary science in English certainly owe some of their significant differences to the linguistic medium. The main parts of this study will explore how this process of adaptation and subsequent further development happened for Latin, by considering examples from various epochs (part 2) and by describing its linguistic manifestations (part 3). But let us first consider a few quite arbitrary, close at hand examples of the problematic translatability of scientific concepts in order to illustrate the range of the difficulty of translatability.

(i) What do the Greek word λόγος, central to Greek philosophy and science, and its main Latin translation, *ratio*, mean in English? Depending on the context, several different words can be used to translate it. We could try to capture the broad spectrum of the meaning of λόγος as 'a coherent utterance (from "word" to "speech" to "treatise") with a logical [!] foundation, in contrast to a fabulous (μῦθος = *fabula*) one that lacks this special qualification; by its nature of being bound by logic [!], it can also denote a (mathematical) ratio [!]'. Thus, a long English sentence is required, and it still has to return to the words of Greek and Latin stock 'logic' and 'ratio', and thus becomes circular. To complicate things even further, there are clearly already significant differences between λόγος and *ratio* – the latter may, for instance, also render ἀναλογία – hinting that the Romans found it difficult to come to terms with the Greek concept λόγος too.[14] The author of *Beowulf* would have been at an utter loss to convey the meaning of λόγος in Old Eng-

ferent intention, that of defining his auxiliary language, *latino sine flexione*). To this a lot of new scientific terminology from the past century would have to be added (on which see chap. 16 §1 below).

13 Gordin (2015b: 4) attempts a tentative and rather generous list, and ends up with seventeen languages.

14 The word was certainly striking to early Romans: Plautus pokes fun at *logos*-mongers (*Stichus* 2.383, ed. Lindsay): *Non vendo logos.*

lish, as he did not have loanwords such as ‘ratio’ and ‘logic’ at his disposal. There are languages that consciously avoid borrowing, in Europe especially Icelandic. In Icelandic ‘logic’ is *rökfræði*, which can be analysed as *rök* (‘reason, explanation’) and *fræði* (‘study, theory’). But although the word is made up of Germanic constituents, the concept is not native but framed to fit the Greek one, typically for a Germanic language by using a compound. It may be added that Icelandic has never had the status of a widely used ‘language of science’ for which such purism might have been hard to maintain.[15] It may be objected that such ‘polysemous’ words as λόγος are in general bad for science and that the term λόγος has given rise to more mumbo-jumbo than real science. But from within a language it is not at all trivial to see whether a general term makes sense in other languages and systems of thought as well. Of course, English has similar terms – think of ‘nature’, for instance (and try to say it in Chinese).

(ii) Things get even worse if a language lacks a grammatical structure on which an utterance to be translated depends. In chapter 8, Seneca will be quoted struggling with saying τὸ ὄν in Latin. Both the article and a present participle of the verb *esse* were missing in (Classical) Latin. English does have a similar form and can say ‘being’, although it too cannot say what would be the most literal translation, ‘*the being’ (in contrast to German *das Seiende*). Of course, a circumlocution is possible, such as *id quod est*, but how clumsy this is only becomes apparent when the Greek concept is used as a building block for more nested, complex thoughts (chap. 24 §3 considers this problem further).

(iii) The problems become truly serious when we leave the circle of the traditional languages of science. For instance, the Amazonian language Pirahã has no words for numbers except relative ones such as ‘small quantity’ and ‘larger quantity’. The simple scientific statement ‘two plus two makes four’ is thus not expressible at all in this language.[16]

It would seem that the more detached a science is from material objects (or, as we tend to say in Latin or Greek, the more ‘abstract’ or ‘theoretical’ it is), the more central its language becomes. In mostly descriptive sciences such as (traditional) botany or (pre-biochemical) medicine, the teacher may simply point to one of his objects (say, a plant or a symptom of a disease) and define its name with an arbitrary (although within his intellectual context unambiguous) term, thus teaching by what used to be called ostension.[17] The reference name used may well be from

15 Some more features of Icelandic are discussed in chap. 23.
16 See Everett (2005). Everett tried to teach speakers Portuguese numbers but had very limited success; most of them did not see why one should bother about precise counting words.
17 This was already pointed out by Poncelet: ‘Ce qui trompe la critique, ici, c’est que le latin a pu assimiler le vocabulaire grec de la faune et de la flore; on croit que le problème est le même pour

an unintelligible foreign language – much Greek was used in Latin treatises on these two sciences in Antiquity – without detriment to the substance. In these sciences, formulations are often of the kind *A habet B* (‘A has/exhibits B’) or *C significat D* (‘C means D’). But the more detached from direct, ostensible experience a science’s content becomes, and the more its importance depends on the relationships between various such non-tangible entities, the more language acquires a key rôle. Examples of this latter kind are mathematics, logic, physics, mechanics, or theology.[18] This is even more the case in philosophy, which is sometimes ‘accused’ of being untranslatable. In these cases, it can be crucial to be able to express an insight with a new word that is preferably, though new, still intelligible at first sight to a speaker – one that fits inconspicuously into the pre-existing web of words of a language. This can happen by compounding or by using syntactic structures to mirror a relationship of, for example, causality, concession, or mutual interaction. Some languages, such as Greek or German or, even more so, agglutinative languages, are very open to accepting newly made words or constructions, while others, such as French or Latin, are rather of an isolating nature and are uneasy with such new formations; English stands somewhere in between.[19] Interestingly, in ‘abstract’ sciences Greek words in Latin texts tend to be much rarer. In modern texts, the conspicuous exception to this rule is philosophy, which tends to use a vocabulary that is very heavily enriched with Greek and Latin loanwords, which, however, in some instances have changed their meaning strongly over the centuries.[20] This can happen all the more easily because their content is neither in a constant feedback loop between an easily verifiable object and itself, nor occupies a well-demarcated space within the web of words of the language in question.

Cicéron; or, il n’en est de rien: dans le cas des mots dits “concrets”, la définition existe, mais elle est simple et instantanée, la vue de l’objet concret la remplace sans le secours des articulations fondamentales de la langue’ (‘What misleads the critics here is that Latin was able to assimilate the Greek vocabulary of fauna and flora; one concludes that the problem is the same for Cicero; however, this is not at all the case: in the case of so-called “concrete” words, the definition is simple and instantaneous, the sight of the concrete object provides it without the help of the fundamental articulations of language’; 1957: 51).

18 Which is, at least in scholasticism, considered a scientific discipline; see chap. 1 below.

19 This is also stressed by Thielmann (2009), who compares German and English as languages of science. However, he seems to reach somewhat extreme and questionable conclusions, for example that German seeks hermeneutics, English is hermetic (302), and that the use of English by German scientists is ‘fatal’ (‘disastrous’; 317) in its consequences. His argument that ‘because’ and *weil* do not cover the same ground (316) becomes much less convincing when we remember that *weil* renders both ‘as’ and ‘because’.

20 An example of this is ‘objective’, encountered below (chap. 3 §§1–3). Some German philosophers (such as Heidegger) have tried to avoid such potentially dangerous borrowings altogether.

Although we shall not concentrate on philosophy here but rather remain within the confines of the sciences,[21] which are more restricted by such feedback loops, the focus in this book will be on more abstract scientific language and its development, indeed mostly on more 'abstract' natural and human sciences.

On technical languages in general

§3 Scientific language is a kind of technical language (German *Fachsprache*).[22] A technical language may be described as containing, besides words and structures from everyday language, a subset of specialised words and, possibly, syntactic structures, or at least a predilection for some such structures not shared by everyday language which have the aim of providing optimal communication between specialists.[23] Scientific language is the *Fachsprache* used in fields that work according to scientific standards (see chap. 4). For many fields, such standards can be seen developing in the surviving literature from Antiquity and the Middle Ages. Specialists of a given field quite naturally tend to develop their own kind of *Fachsprache*, as especially mathematicians, historiographers, orators, medical doctors, and jurists did in Antiquity.

Modern technical languages have been extensively studied by linguists.[24] Coșeriu (2007) defines them as 'sociolects' and 'functiolects', that is, as subsets of a language defined respectively by their social rôle and their function. Technical languages may be characterised by criteria such as

- a didactic component (teaching the recipient something);
- use by a special group of people, not by all speakers;
- previous knowledge being required for comprehension;

21 For some remarks on the relation between philosophy and science and its change over time, see chap. 3 §6 below.

22 See Sallmann (2015). There is a discussion of contemporary attempts to define *Fachsprache* in Fögen (2009: 13–19). Fögen (22) rightly stresses the difficulties in demarcating technical from belletristic literature in Antiquity; the same is true for the Middle Ages.

23 See Fluck (1996: 11–12). Thus, *Fachsprachen* are to be differentiated from *Sondersprachen* ('special languages') and jargons, which may have many other functions, such as the building of a group identity (e.g. in student jargon). Cicero was already aware of technical languages: *Quod quidem nemo mediocriter doctus mirabitur cogitans in omni arte, cuius usus vulgaris communisque non sit, multam novitatem nominum esse, cum constituantur earum rerum vocabula quae in quaque arte versentur* ('Therefore, no one who is tolerably educated and considers all the arts whose use is not widespread and common will wonder that much novelty of naming is found there: these names constitute the vocabulary which is treated in each art'; *De finibus* III.1, ed. Moreschini, p. 90).

24 e.g. Fluck (1996); Hoffmann (1987).

- having the function of sharing knowledge about the technical subject;
- the usual social component of human speech being irrelevant (impersonal structure).

All of this makes a certain type of language especially appropriate for technical languages. The virtues of technical languages include precision, efficiency, brevity, clarity (for specialists only!), anonymity, stability of vocabulary, and a one-to-one-correspondence between words and objects. Some of these characteristics will be used when we try to define scientific language (chap. 4 §7). Of course, there are also non-scientific types of technical languages, for instance technical texts about how to perform rituals, or manuals by and for craftsmen. The kind of language used in the scientific subtype can be expected to be more uniform than *Fachsprache* in general: magicians using their *Fachsprache* are likely to speak very differently compared to scientists. But it will become evident that the spectrum for scientific Latin was still much larger than that of the modern languages.

Part 1 will show how difficult it is to demarcate what 'science' is. Instead of speaking of the language of science, in which case one has to know what can pass as science and what cannot, one might be tempted to avoid this difficulty by simply speaking of scholarly or academic language (German *Gelehrtensprache*), which would be the language used in academic written communication. This might indeed be feasible from the time when universities begin to form (ca. AD 1200) onward, but before this date it would be rather arbitrary to decide what authors can be called academic: many scientific authors worked privately or at institutions that can hardly be called academies in any sense. Besides, it seems a bad idea to define scientific language on purely sociological grounds based on academic structures: for instance, some magical papyri[25] might well stem from some kind of magician 'academy', but their language is very different from the language used by scientific authors and is certainly not part of our scope. Therefore, an attempt is made to demarcate first what approaches can be and have been called scientific in diachronic terms (part 1), and then to consider the language in texts that fulfil such criteria (parts 2–3). The semantic differences between German *Wissenschaftssprache* and 'language of science' correspond to those between *Wissenschaft* and 'science' discussed below (chap. 1).[26] As the title of this book

25 Many of which are can be found in *Papyri graecae magicae*, ed. Preisendanz.

26 In a Greifswald talk, Michael Gordin (2015a) concluded that there is no way in English to say *Wissenschaftssprache*, and went on to use the German term.

hints, we shall use ‘science’ in a relatively wide sense that includes some types of ‘learning’ other than strict science.

§4 The present writer’s native tongue is German, so why is this book written in English and not in German? Apart from practical reasons – that German is less and less read outside the German-speaking areas – the deeper reason is that English as a language of science has more in common with Latin, whereas German has more in common with Greek.[27] It would seem that English is a dignified heir of Latin (as French could also have been). Latin, French, and English may be described as more ‘analytic’ and ‘lexical’ in how they express novelty; new words are accepted only reluctantly. German, on the other hand, works differently: it uses key features of its structural, synthetic richness, such as compounding, to capture facets of reality (*Sachverhalte* – a word that is an excellent example of what has just been said), besides also by nominalising all kinds of parts of speech, especially verb forms (such as *das Sein*, *das Vorhanden-Sein*, etc.).[28] Much of German *Geisteswissenschaft*[29] and philosophy works like this, and its richness is therefore hardly translatable into ‘analytic’ languages such as English or French. In this respect, German functions like Greek. Similar problems to the translation and transfer of thought from Greek to Latin thus occur between German and English. Conversely, ‘analytically’ trained people will tend to think that Greek and German are especially good at conjuring up mumbo-jumbo. Depending on whether it is penned in English or German, even a scholarly book such as the present one will differ significantly despite the *Begriffsgemeinschaft* we share today. Writers in Antiquity who wrote in both Greek and Latin will have felt a similar difference in expressing themselves.

27 As will become evident in chap. 24 below.
28 A typology of languages as more lexical or grammatical was proposed in passing by de Saussure: ‘on pourrait dire que les langues où l’immotivité atteint son maximum sont plus *lexicologiques*, et celles ou il s’abaisse au minimum, plus *grammaticales*’ (‘one might say that languages where immutability reaches its maximum are more *lexicographical*, and those where it is minimal, more *grammatical*’; 1972: 182 [263], italics in original).
29 Gadamer (1990) or Snell (1952) are good examples. The same is, of course, true for many German philosophers, such as Hegel or Heidegger.

Part 1 **Semantics of the term ‘science’**

This first part of the book begins by taking a look at the meaning of the words for ‘science’ in the major modern European languages that fall within the modern *Begriffsgemeinschaft* (chap. 1). Then their corresponding terms in Greek and Latin are examined (chaps 2–3); since these languages did not yet belong to the modern *Begriffsgemeinschaft*, the situation will be more complicated. The nature of science (and whether it has a ‘nature’ at all) is a topic that has been hotly debated for a long time and which cannot be resolved here for good. Only after a thorough description of the semantics of the words for ‘science’ in the languages most relevant to the present study can we try to extract common criteria and consider whether they make up a coherent and organic whole (chaps 4–5). First (chap. 4 §§1–4), a few positions are summarised to illustrate the problem. Then an approach that tries to find a middle way between a purely normative and a purely descriptive approach to science will be proposed: broad enough to serve in different epochs and cultures, at least for the scope of the present study, yet not containing any activities we would clearly not want to include under the heading ‘science’. It will, hopefully, also become clear that the opposition between scientific ‘relativism’ and ‘realism’ can and should find a compromise resolution. The problem of demarcating science from other human activities concludes this first part of the book (chap. 5). Part 2 will add a diachronic dimension to the Greek and Latin terms for science, as well as an assessment of what has been seen as science since Antiquity, in order to produce a fuller picture.

1 Modern languages: *Wissenschaft*, *science*, наука, επιστήμη

§1 In order to approach the question of what science is, the use of the corresponding words for 'science' in some major European languages of science is studied here first: a Romance one (French), a Germanic one (German), a Slavonic one (Russian), and Modern Greek, which, although hardly used today for scientific communication, is important as the successor of Ancient Greek. In keeping with the *Begriffsgemeinschaft* described above, in each of these languages there is one term that is used exclusively, or nearly so, to express what in English is called 'science': *science*, *Wissenschaft*, наука, and επιστήμη, respectively.

§2 The French term *science* still has a broad scope similar to that of its Latin parent (on which see chap. 3 below). It also has a wider and a narrower sense, the latter being the one we are interested in. The wider sense corresponds to English 'knowledge'. For instance, Le Robert defines the narrower one:[1]

> Connaissance exacte et approfondie. [...] Ensemble de connaissances, d'expériences. [...] [C]onnaissances étendues sur un objet d'étude, d'intérêt général. [...] Art ou pratique qui nécessite des connaissance, des règles.
> 'Exact and thorough knowledge. [...] A body of knowledge, experiences. [...] Extensive knowledge of an object of study of general interest. [...] An art or practice which requires knowledge, rules.'

Another definition – which is possibly even closer to the Latin *scientia* – defines *science* as (Blay 2005: 734)

> la connaissance claire et certaine de quelque chose, fondée soit sur des principes évidents et des démonstrations, soit sur des raisonnements expérimentaux, ou encore sur l'analyse des sociétés et des faits humains.
> 'clear and certain knowledge of something, based either on obvious principles and demonstrations, or on experimental reasoning, or again on the analysis of societies and human givens'.

This is a list that seems to be designed to correspond to mathematics, natural science, social sciences, and human sciences[2] respectively. This possibility of

1 *Le grand Robert* (s.v. *science*).
2 The somewhat old-fashioned term 'human sciences' will be used throughout this book to denote German *Geisteswissenschaften* or French *sciences humaines*, as it contains the epithet 'science' unlike the now more fashionable 'humanities'. As well as lacking a connection with

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using *science* in both the wider and the narrower Latin sense of the word may be responsible for the fact that French authors often take science to be something quite general: Lévi-Strauss (1962: chap. 1), for instance, speaks of a 'science du concret' in the 'pensée mythique' of pre-literate cultures. This ambiguity may also explain the arrangement of the large and ambitious *Histoire générale des sciences* (Taton 1958–1981): it does not define its field of study, and expressly does not cover the human sciences and technology (2:vi), but the work still begins with 'les temps préhistoriques', then covers Egypt, Mesopotamia, China, and India in detail. After this, however, it is acknowledged that (1:202):

> Cette civilisation hellène, si brillante, devait, en effet, être à l'origine d'une nouvelle conception de la signification, du rôle et de la structure d'ensemble de la science, conception beaucoup plus profonde, plus abstraite et plus rationnelle que toutes celles qui l'avait précédée.
> 'This brilliant Greek civilisation must indeed have stood at the origin of a new conception of the meaning, the rôle, and the overall structure of science, a conception that was much deeper, more abstract, and more rational than all those that had preceded it.'

So, the authors clearly see the qualitative difference that is reached in ancient Greece, but the French word *science* is capable of standing for the development before and after that caesura, of covering *science* in a broad sense and in a narrow sense with the same word.

A glance at the French Wikipedia article on *science* shows that the term is often combined with adjectives:[3] *sciences fondamentales, appliquées, nomothétiques, idiographiques,*[4] *empiriques, logico-formelles, de la nature, humaines, sociales*. It thereby includes, for example, historiography, literary criticism, psychology, jurisprudence, and engineering, all of which would probably not be called 'sciences' in contemporary English. However, there is no consensus in a strongly secularised France as to whether *théologie* can be called a *science*. Indeed, Larousse (s.v. *théologie*) defines it as a mere 'study': 'Étude concernant la divinité et plus généralement la religion' ('Study concerning the Godhead and the most gen-

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'science', the latter term has the undesirable connotation of 'humanism', from which the word is derived. In 1926, Fowler (quoted in *OED*, s.v. 'humanities', 2a) still wrote of '[t]he Humanities, or *Litteræ humaniores*, […] an old-fashioned name for the study of classical literature'. The first clear case of 'humanities' in contrast to 'sciences' at universities quoted in the *OED* is from 2003 (2b). On the uneasy relation between Renaissance humanism and science, see chap. 12 below. I hold that the human sciences are (i.e. can and should be) a scientific undertaking, not a humanist, rhetorical 'anything goes'.

3 http://fr.wikipedia.org/wiki/Science#Classification_des_sciences (24 September 2018).

4 i.e. concerning individual things.

eral notions of religion'). Nonetheless, there exists a contemporary periodical called *Revue des sciences religieuses* (ISS. 0035-2217). *Philosophie* would also not usually be seen as a *science* today, neither in French nor in the other modern languages under consideration, although it is less clear whether it might not use *des méthodes scientifiques*. Giard (2003: 62) sums up that

> l'embarras demeure sur la signification de 'science', qui varie selon la date, le genre littéraire, et le contexte d'emploi, tout comme subsiste l'ambiguïté sur les modèles de scientificité dont relèvent ces autres sciences dites sociales, religieuses, humaines, etc.
> 'the dilemma remains about the meaning of "science", which varies according to date, literary genre, and context of employment, just as the wavering persists concerning the models of scientificity to which these other – social, religious, human, etc. – sciences relate'.

This complicated topic is further discussed below (chap. 3 §6).

A glance at other Romance languages shows that use in Italian is similar to French,[5] but this is not universal among the Romance languages. Contemporary Spanish tends to restrict *ciencia* – rather like English – merely to the natural and mathematical sciences. For instance, universities often differentiate a *facultad de ciencias* (natural sciences) from a *facultad de letras* (human sciences). But this practice seems to be a recent innovation. Indeed, it is not uniform in the vast territory where Spanish is spoken. For instance, the Universidad Nacional Mayor de San Marcos in Lima (Peru) has a Facultad de Letras y Ciencias Humanas. The *Diccionario de la lengua castellana* of the Real Academia of 1823 (p. 196) still presents the Romance meaning we have met in French:

> Ciencia: sabiduría de las cosas humanas por principios ciertos, como los de las matemáticas. Llámanse también ciencias algunas facultades, aunque no tengan esta certidumbre de principios, como la filosofía, la jurisprudencia, la medicina, etc.
> 'Science: knowledge of human matters through certain principles, such as those of the mathematical sciences. Some other fields are also called "sciences" although they lack this certainty of their principles, such as philosophy, jurisprudence, medicine, etc.'

This ambiguity in Spanish may be an indication that the old Latin concept of *scientia* in the Romance languages may be about to undergo significant changes due to English influence in the near future.

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5 Petruccioli's (2001–2004) large and ambitious Italian encyclopaedia of science treats all kinds of science but does not define its topic (just as Taton 1958–1981 did not). It includes Palaeolithic and pre-Colombian *scienza*. The majority of the contributors wrote their articles in other languages that were subsequently translated into Italian. This is reflected in a rather heterogeneous approach to what constitutes science. Some contributors mention this problem (e.g. Staal 2001: 611).

§3 The German word *Wissenschaft* is derived from *wissen* (‘to know’) < PIE **u̯eid* (οἶδα, *video*; ‘to spot’) plus *-schaft*, which is etymologically identical with English *-ship* and also sometimes used in the same way (e.g. ‘partnership’ = *Partnerschaft*), but more often corresponds semantically to English *-hood* (e.g. *Ritterschaft* ‘knighthood’, indicating the entirety or community of knights and by extension also their forms of behaviour).[6] Thus, *Wissenschaft* quite literally means the ‘entirety of knowledge’. The Grimm dictionary notes that before the seventeenth century, German preferred the word *Wissenheit,* a word that is now extinct. *Wissenheit* had a wider range, it comprised all of *scientia* and also *conscientia*.[7] *Wissenschaft* only becomes common for ‘objective’ scientific knowledge in the seventeenth century, when it quickly gains general acceptance. It has two distinct meanings. The first, *notitia, cognitio* (‘a piece of news or knowledge’; German *Nachricht, Kunde, Einzelerkenntnis*), has disappeared almost completely today; the second is defined as *scientia* in Grimm. Comenius 1643 (quoted in Grimm) tells us that true knowledge of a thing is *Wissenschaft* and wrong knowledge *Irrthumb* (‘error’; modern spelling: *Irrtum*). So it would seem that *Wissenschaft* at least roughly corresponds to French *science* in the narrow sense. Meyer’s *Konversationslexikon* elucidates in detail (s.v. *Wissenschaft*):

> Wissenschaft, zunächst das Wissen selbst als Zustand des Wissenden, sodann der Inbegriff dessen, was man weiß; im engern und eigentlichen Sinn der vollständige Inbegriff gleichartiger, systematisch, also nach durchgreifenden Hauptgedanken, geordneter Erkenntnisse. Diese an sich bilden den Stoff, die Materie einer bestimmten W.; durch die systematische Form wird er zum wissenschaftlichen Gebäude (Lehrgebäude), welches, regelrichtig und den Gesetzen der Logik gemäß aufgeführt, System (s.d.) heißt. […] Je nachdem bei einer W. mehr entweder ihre Begründung oder ihre Anwendung in Betracht kommt, unterscheidet man reine und angewandte W.; je nachdem das Wissen, das deren Stoff ausmacht, empirisches oder rationales, reales oder normales, Erfahrungs- oder philosophisches ist (vgl. Wissen), werden die Wissenschaften selbst in empirische und rationale, oder Real- und Formal-, oder Erfahrungs- und philosophische Wissenschaften eingeteilt. Aber nirgends stehen die einzelnen Wissenschaften so getrennt voneinander, daß nicht ein Eingreifen der einen Art in die andre möglich, ja sogar notwendig wäre; einzelne Wissenschaften bestehen sogar nur in dieser Vermischung (gemischte Wissenschaften).
> ‘Science, first of all knowledge itself as a state of the knower, then the embodiment of what is known; in the narrow and genuine sense the complete embodiment of consistent, systematically (i.e. according to sustained main ideas) ordered pieces of knowledge. These by themselves form the substance, the matter of a particular science; put in a systematic form this becomes a scientific edifice (doctrinal edifice), which, if established correctly and according to the laws of logic, is called a system (q.v.). […] Depending on whether a science has

6 See Kluge (s.v. *-schaft*).
7 See Grimm (s.vv. *Wissenschaft*, *Wissenheit*).

more to do with either explanatory force or application, a distinction is made between pure and applied science; depending on whether the knowledge that constitutes it is empirical or rational, real or formal, experiential or philosophical (see Knowledge), the sciences themselves are divided into empirical and rational, or real and formal, or experiential and philosophical. But nowhere are the individual sciences so separate from one another that overlaps between one kind and another are not possible, nay even necessary; some sciences even consist exclusively of such a mixture (mixed sciences).'

This is very similar to the French understanding. Zedler's earlier *Universal-Lexicon*, one of the largest printed encyclopaedias of all time, provides a very detailed treatment of *Wissenschafften* (1731–1754: 57:1399–1523). At the very outset, the term *Wissenschafften* (in the plural) is equated with Latin *scientiae;* the discussion adds (1399)

dass es eine Lehre bedeute, deren Wahrheiten erkannt werden, da es dann wieder eine zweyfache Absicht hat. Denn entweder nimmt man selbiges in weitläufigem Sinn vor eine jede Lehre, sie mag gewiß oder nur wahrscheinlich seyn, wenn man z. B. die Disciplinen der Philosophie, oder einer anderen Gelehrsamkeit, Philosophische Wissenschafften zu nennen pflegt [...].
'that it means a teaching whose truths are recognised, which again has a twofold intention. For either one takes the same thing in a broad sense for any teaching, be it certain or only probable, if, for example, one is in the habit of calling the disciplines of philosophy, or of other scholarship, philosophical sciences [...].'

The crucial question of how certain knowledge must be to merit the name 'science' will be encountered again below. The account goes on to present a large overview of the many fields of *Wissenschafft*, a brief history of science and learning (with a strong anti-mediaeval bias), and many other things in a rather hotchpotch way. The article in the *Universal-Lexicon* also stresses (1433) that *Wissenschafft* is acquired by four means: books, one's own thinking, teaching, and experience. This is a broad approach that would work for scholastic as well as for experimental 'science'. It is interesting to note that neither of these German treatments mentions requirements that possible topics of *Wissenschaft* have to meet. Indeed, anything that can be studied according to their descriptions can qualify as such. Thus, present-day German *Wissenschaft* basically comprises everything that can be studied at a modern university, and the German *Wissenschaftler* corresponds to both the English 'scientist' and 'scholar',[8] although the latter may also be called *Gelehrter* in German. Indeed, German also has the abstract term *Gelehrsamkeit*, which roughly corresponds to English 'scholarship', but both it and *Gelehrter* are rarely used for living people today, and these words may soon become obsolete altogether.

8 Also pointed out by von Weizsäcker (1991: 154–157).

As a language that is fond of free compounding, German can, of course, freely derive further terms such as *Wissenschaftsbegriff, Wissenschaftsbetrieb,* or *wissenschaftsgläubig; Wissensgebiet* or *Wissenszweig* ('domain of knowledge') is a wider term than *Wissenschaft*. Heraldry, for instance, will qualify as a *Wissensgebiet*, but hardly as a *Wissenschaft,* although perhaps as a *Hilfswissenschaft*. This richness of terminology that can be created on a more or less ad hoc basis is unique to German among the languages considered in this chapter. The German term for 'science' may well be the one with the broadest spectrum of meaning of those considered here; in German there can even be *Liturgiewissenschaft*[9] or *Bibliothekswissenschaften* ('scientifically' studying the liturgy or organisation of book collections).

§4 The Russian word for 'science' is наука, a feminine noun derived from the verb научить ('to teach') and its reflexive counterpart научиться ('to learn') – thus corresponding closely to *disciplina* (from *discere*) in Latin and to *Gelehrsamkeit* ('learning') in German. The Russian words are derived from the Slavonic root **učȋti*, which is a cognate of Sanskrit *√uc* (present *ucyati*, 'to be accustomed to').[10] To this root the prefix на- is added, which in this case stresses that the action was 'performed to a point of satisfaction'.[11] The term наука, like German *Wissenschaft*, can be used for the whole range of natural, historical, literary, social, and technical 'sciences'. The *Большая советская энциклопедия* describes наука as 'сфера человеческой деятельности, функцией которой является выработка и теоретической систематизация объективных знаний о действительности' ('the sphere of human activity whose function consists in the development and theoretical systematisation of objective knowledge about reality [in the sense of German *Wirklichkeit*]').[12] Thus, наука is a special type of знание ('knowledge'). Further on in the entry, the sciences are depicted in a diagram (fig. 1) as grouped together, according to the degree of organisation in their object (nature, man, society), as естественные ('natural', literally 'essential'), социальные ('social'), and философские ('philosophical') ones, with technology and mathematics as side-branches of the natural sciences.

9 Martimort's *L'église en prière* (1961) became *Handbuch der Liturgiewissenschaft* in its German translation.
10 See Derksen (s.v. *učȋti*); Vasmer (s.v. учить).
11 This is one of three main meanings of this prefix as defined in Wade's (2011: 286) grammar.
12 действительность is a rendering of German *Wirklichkeit*; it is derived from действие (equivalent to German *Wirkung*), ultimately from the obsolete дѣять, now replaced by делать, the normal word for 'to do'. Thus, it means more than the English 'reality'; it comprises everything that is in some way or other effective.

Fig. 1: The sciences according to *Большая советская энциклопедия* (s.v. наука).

For the *nomen actoris* ‘scientist’, Russian uses the word учёный, literally ‘one who has learned’, from the same root without the prefix на-, thus formally corresponding closely to the German *Gelehrter*. It becomes evident that the Russian categories are very similar to the German ones. This was only to be expected, as Russia entered the early modern European cultural sphere quite late and largely through Germans (beginning in the time of Peter the Great, 1672–1725).

§5 For Modern Greek, the Μπαμπινιώτης dictionary defines επιστήμη (first and main meaning):

> Το σύνολο συστηματικών και επαληθεύσιμων γνώσεων, καθώς και η έρευνα αυστηρώς καθορισμένων πεδίων τού επιστητού με συγκεκριμένες και ορθολογικές μεθόδους, λ. χ. την παρατήρηση, το πείραμα, την υπόθεση, την επαγωγή.
> ‘The entirety of systematic and verifiable knowledge as well as research using specific and rational methods in strictly defined fields of the knowable, e.g. observation, experiment, hypothesis, induction.’

Then examples are given, divided into theoretical (θεωρητικές), human (ανθρωπιστικές), and positive (θετικές, i.e. natural) sciences. Longer lists in a similar vein are proposed by the authors of the Greek Wikipedia:[13]

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13 http://el.wikipedia.org/wiki/επιστήμη (17 December 2013). The main divisions were not challenged for two years. Later (5 May 2019), the last category, Επιστήμες του σύμπαντος, was removed from the list; its sciences have been reallocated (e.g. Θεολογία is now a human science). Thus, the subcategories seem to be disputed to some degree, but not what belongs to the list.

> Θετικές επιστήμες (Φυσικές επιστήμες (Φυσική, Χημεία), Επιστήμες γης και περιβάλλοντος, Μαθηματικά, Στατιστική, Πληροφορική), Εφαρμοσμένες επιστήμες (Επιστήμη μηχανικού, Επιστήμες υγείας, Ιατρική, Φαρμακευτική, Γεωπονία, Παιδαγωγική, Επιστήμες διοίκησης), Κοινωνικές επιστήμες (Ψυχολογία, Πολιτικές επιστήμες, Νομική, Κοινωνιολογία, Οικονομικά, Γεωγραφία), Ανθρωπιστικές επιστήμες (Φιλολογία, Ιστορία, Αρχαιολογία, Ανθρωπολογία, Φιλοσοφία, Ανατομία), Επιστήμες του σύμπαντος (Θεολογία, Κοσμολογία, Αστρονομία, Μεταφυσική).
> ‘Positive sciences (physical sciences (physics, chemistry), earth and environmental sciences, mathematics, statistics, information science), applied sciences (mechanics, health sciences, medicine, pharmaceutics, agricultural science, pedagogy, administrative sciences), social sciences (psychology, political science, law, sociology, economics, geography), human sciences (philology, history, archaeology, anthropology, philosophy, anatomy), sciences of everything (theology, cosmology, astronomy, metaphysics).’

The list is at least equally comprehensive as the similar ones in German and Russian met above: one starts to wonder how old this wide consensus among European languages diverging from the English understanding of ‘science’ is. For a first impression, let us take a quick look at contemporary Latin (historical Latin and Ancient Greek are considered in the next chapter).

§6 The Latin Wikipedia[14] (on which see chap. 16 §1 below) distinguishes the following fields of *scientia*:

- *Scientiae empiricae rerum naturalium: Astronomia, Biologia, Chemia, Geographia, Geologia, Medicina, Physica.*
- *Scientiae axiomaticae: Logica, Mathematica.*
- *Scientiae rerum humanarum: Anthropologia, Archaeologia, Historia, Ius, Linguistica, Oeconomia, Philologia, Philosophia, Civilitas, Psychologia, Scientia mediorum, Scientia religionum, Scientia socialis, Sociologia.*
- *Scientiae arcanorum: Astrologia, Theologia.*

By being marked as secret or mysterious sciences, the final group is clearly not put on the same level as the others, and there may be the suggestion that they are actually pseudo-sciences: the article on astrology claims it is an art, but the one on theology states it is *scientia rerum divinarum*.[15] Thus, the Latin Wikipedia’s distinction follows the traditional German paradigm and also uses *scientia* like German uses *Wissenschaft*. The differentiation between *artes* and *scientiae* in Vicipaedia – the former also containing the *artes liberales*, the second all the German

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14 https://la.wikipedia.org/wiki/Scientia_(ratio) (5 May 2019).
15 Indeed, Thomas Aquinas proved that theology is a *scientia (Summa theologiae* Ia, q. 1, a. 2, Leonina edition, vol. 4, pp. 8–11). The main argument is that it *procedit ex principiis*. On this issue, see Zimmermann (1981).

Wissenschaften – makes it evident that *ars* and *scientia* are still to some extent perceived as overlapping (as we shall see, they have been for a long time), and *scientia* in Latin is still a much wider concept than the English 'science'. Exchanges on the discussion pages are to a large extent held in English, so one would expect some English conceptual influence, but in the case of *scientia* this cannot be discerned at all; rather, we have what might by now be called the normal 'international', not the English, list of sciences.

§7 In summary it may be said that the disciplines that are candidates for being called 'science' are often classified into mathematical, natural, historical, literary, social, and technological ones. All of these fields are usually included in the terms for 'science' in French, German, Russian, and Modern Greek. Modern English, however, tends to differentiate between science and scholarship, grouping at least historical and literary studies into the latter category. In the following table, we try to compare what disciplines the five languages would consider as sciences; this is obviously a simplification to some extent and may be open to further discussion. The entries are based on a list in Schurz (2008: 32–33) intended to enumerate the fields of *Wissenschaft*.[16] Dictionaries and reference works in the relevant languages were consulted.[17] The table contains 'X' where the corresponding word for 'science' is used in the description of the field in question, '(X)' if it is used only for some fields in a category, and '?' if it is used tentatively or the situation is unclear. The corresponding Latin term has been added in the final column, although there never was a consensus as to what disciplines were to count as *scientiae* (or *disciplinae*) and what as *artes*. The classification of Cassiodorus was applied where applicable,[18] and common Latin designations for the fields have been added. The classification of the sciences has, of course, been a controversial issue ever since a category 'science' began to be used.[19] It must also be added that these are at best tendencies, as *ars* and *scientia* can be seen as two approaches which can both be taken to the same topic. Thus,

16 He differentiates the following types according to their topics: (i) nature; (ii) technology ('Maschinenbau, Elektrotechnik, Computerwissenschaft'); (iii) man; (iv) society; (v) history; (vi) culture ('Jurisprudenz, Sprachwissenschaft, Literaturwissenschaft, Musikwissenschaft'); (vii) formal structures (such as mathematics), (viii) general foundations of mental cognisance of the world ('geistige Welterfassung'), such as philosophy; and (ix) God: theology, religious studies ('Religionswissenschaft').

17 For English: *Encyclopedia Britannica* [online]. For French: *Le Robert*. For German: *Duden* and Schurz (2008). For Russian: *Большая советская энциклопедия*. For Modern Greek: Μπαμπινιώτης.

18 From *Institutiones*, ed. Mynors; see chap. 9 §1 below.

19 Some of its earlier stages are covered by Mariétan (1901); more details in chap. 10 §6 below.

medicine as an *ars* will tend to be focused on the actual treatment of patients, whereas as *scientia* it will tend to be focused on theoretical studies. Uncertainty increases because the branches and their names stem from a long time span and usage was not always the same. A closer look at the relationship of the Latin terms *scientia*, *disciplina*, *ars*, *historia*, and *philosophia* will be taken below (chap. 3).

Table 1: What fields tend to be perceived as 'sciences' in different languages?

Field of study	Examples	Main method	English	French	German	Russian	Modern Greek	Latin
			science	*science*	*Wissenschaft*	наука	επιστήμη	
numbers, abstract formal structures	mathematics, logic, (theoretical) computer sciences	deductive	X	X	X	X	X	*scientia formalis*
nature	physics, chemistry, biology, geology	inductive, experimental	X	X	X	X	X	*scientia naturalis*
man as part of nature	anthropology, archaeology, medicine	various	X	X	X	X	X	*ars/ scientia*
man's soul and behaviour in general	psychology, sociology	today mostly statistical	(X)	X	X	X	X	*scientia*
man's language	linguistics, grammar	various, e.g. comparative	–?	X	X	X	X	*ars/ scientia*
man as organiser	jurisprudence, politology, economics, ethics	study of sources, statistics	–	(X)	X	X	X	*ars/ scientia*
man's culture	literary studies, philology, historiography, musicology	study of sources	–	X	X	X	X	*ars/ historia*
organisation of data	*Bibliothekswissenschaft*, information theory	various	(X)	(X)	X	(X)	(X)	*ars/ scientia* ?
religion	theology, religious studies	study of scripture	–	–?	X	X	X	*scientia*
philosophy	ontology, epistemology, metaphysics	abstract thought	–	–?	(X)	(X)	(X)	*philosophia*

The fields are roughly ordered from nature, through man, to everything (unlike the list in Schurz). At a glance, it becomes clear that English differs most strongly from the other languages. For the (less material and formal) items lower down in the table, contemporary English would mostly use terms such as ‘academic research’, or just call them ‘studies’ or ‘learning’,[20] so *Wissenschaft* (and the words in the other languages studied) can be translated as ‘academic field’ or more precisely ‘studies using a scientific method’: for the time being, the adjective ‘scientific’ is still more broadly applicable than its corresponding noun in English. The question now arises as to how English came to deviate so conspicuously from the other languages.

The semantic evolution of ‘science’ in English

§8 In present-day English, the meaning of ‘science’ tends to be much more restricted than in the other languages we have considered: ‘sciences’ are mostly the natural sciences and usually also mathematics. The near complete concord among the other studied languages makes it a priori likely that English restricted the meaning of the word ‘science’ relatively recently. In fact, the *OED* (s.v. ‘science’) puts this as:

> b. In modern use, often treated as synonymous with ‘Natural and Physical Science’, and thus restricted to those branches of study that relate to the phenomena of the material universe and their laws, sometimes with implied exclusion of pure mathematics. This is now the dominant sense in ordinary use.

Some of the quotations provided by the *OED* hint that the word’s meaning has shifted over the past few centuries, apparently from corresponding to Latin *scientia* and French *science* (in a broad and a narrow sense of ‘knowledge’ versus methodologically found ‘certain knowledge’), through being equivalent to the German *Wissenschaft* (which corresponds roughly to the narrower meaning), to the even narrower contemporary meaning:

> 1697 tr. F. Burgersdijck *Monitio Logica* ii. xx. 99: The word science is either taken largely to signifie any cognition or true assent; or, strictly, a firm and infallible one; or, lastly, an assent of propositions made known by the cause and effect.
> 1753 Johnson Adventurer No. 107. ⁋18: Life is not the object of Science: we see a little, very little; and what is beyond we can only conjecture.

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20 *OED* (s.v. ‘learning’, 3a): ‘Knowledge, esp. of language or literary or historical science, acquired by systematic study’.

> 1882 J. R. Seeley Nat. Relig. 260: Though we have not science of it [supernaturalism] yet we have probabilities or powerful presentiments.
> 1944 J. S. Huxley On Living in Revol. iv. 45: The science of mind developed later than biological science.

The narrow modern English meaning is already mentioned as the main one in the eleventh edition (1911) of the *Encyclopaedia Britannica* (s.v. 'science'):[21]

> a word which, in its broadest sense, is synonymous with learning and knowledge. Accordingly it can be used in connexion with any qualifying adjective, which shows what branch of learning is meant. But in general usage a more restricted meaning has been adopted, which differentiated 'science' from other branches of accurate knowledge. For our purpose, science may be defined as ordered knowledge of natural phenomena and of the relation between them; thus it is a short term for 'natural science', and as such is used here technically in conformity with a general modern convention.

But the first edition of 1771 does not yet know of such a narrowed-down use of the word. The *Encyclopaedia* meant to treat of 'arts and sciences', and indeed its subjects range from practical *artes* (such as 'agriculture' or 'book-keeping'), through sciences (such as 'astronomy' or 'chemistry'), to terms of scholarship and philosophy (such as 'anapest' or 'moral philosophy'). Indeed, the word 'science' is at this point still taken as a very general word, as a kind of general method of philosophy (!) and not worth a detailed explanation. The full article is delimited thus: 'SCIENCE, in philosophy, denotes any doctrine, deduced from self-evident and certain principles, by a regular demonstration.' On the other hand, the word is often used in the general Latin sense of *scientia*, for example in the article on moral philosophy, which starts:

> MORAL PHILOSOPHY is 'The science of manners and duty; which it traces from man's nature and condition, and shews to terminate in his happiness'. In other words, it is 'The knowledge of our duty and felicity;' or, 'The art of being virtuous and happy'.

It is argued that ethics are deducible from human nature and the *conditio humana,* and may therefore qualify as a science, and that, as this also has practical implications, it may equally be called an art. In the sixth edition in 1823, the concept of 'science' had clearly gained importance, judging by the length of the relevant article: three types of science are now distinguished, and only one part of the first

21 https://archive.org/stream/encyclopaediabri24chisrich#page/396/mode/1up.

corresponds to our restricted modern use in the sense of 'natural science'. It is still seen as part of the broader term 'philosophy':

> SCIENCE, in Philosophy, denotes any doctrines deduced from self-evident principles. Sciences may be properly divided as follows: 1. The knowledge of things, their constitutions, properties, and operations: this, in a little more enlarged sense of the word, may be called Φυσικη, or natural science; the end of which is speculative truth. See Philosophy and Physics. – 2. The skill of rightly applying these powers, πρακτικη: The most considerable under this is ethics, which is the seeking out those rules and measures of human actions that lead to happiness, and the means to practise them (see Moral Philosophy); and the next is mechanics, or the application of the powers of natural agents to the use of life (see Mechanics.) – 3. The doctrine of signs, σημαντικε [*sic*]; the most usual of which being words, it is aptly enough termed *logic*. See Logics. [...]

It may be noted that the first recorded occurrence of the word 'scientist' in the *OED* occurs in the same timeframe (1834). We can therefore conclude that the narrowing of 'science' started in the second half of the nineteenth century; this process is still ongoing in the present day, for the broad meaning of *scientia* still lives on in some manners of speaking, like 'the science of things'. The narrower term (corresponding to *Wissenschaft*) was still quite normal at the beginning of the twentieth century, at least for the adjective; in 1923, for instance, Thorndike (1923–1958: 1:290) writes: 'R. Reitzenstein, *Poimandres*, Leipzig, 1904, p. 319. This work is the fullest scientific treatment of the subject.' Today this would be expressed with 'scholarly' rather than 'scientific'; indeed, if we read such a statement today we might (wrongly) suspect that Reitzenstein used methods from the natural sciences for studying his text. Below, in chapter 14 §3, a tentative explanation for the idiosyncratic behaviour of English is proposed.

§9 The complicated situation in which the various European nations do not share a common concept of science, with contemporary English diverging the most strongly, becomes evident to all who read about *Wissenschaftstheorie* in various languages.[22] Thus, contemporary English might have two words for which German and the other languages have only one. The problem in the present context is that the recently changed English semantics are hardly adequate for a historical study focusing on Latin. It may be true that inventors (or discoverers) are free to chose whatever designation they like for completely new phenomena, as for instance the Danish botanist Wilhelm Johannsen did when he coined the word

22 e.g. Gordin (2015b: 3) similarly notes that 'the narrowness of English is distinctive. Other languages, such as French (*science*), German (*Wissenschaft*), or Russian (наука, *nauka*), use the term to encompass scholarship in a broad sense, including the social sciences and often also the humanities.'

'gene' in 1909 and defined what it should mean henceforth.[23] But for phenomena that have been a matter of discussion for millennia, such as science, the history of the concept in question must not be overlooked. If English is currently developing a new, finer differentiation between 'science' and 'scholarship', this may be a useful new nuance, but one would also wish to have a term to designate both of these kinds of activities together. 'Studies' and 'learning' are clearly too broad (one can also perform unscientific, say necromantic, studies), and 'academic fields' defines them in a purely sociological way. A linguistic development of this kind can easily have political consequences too: universities may, for instance, exclude or give less funding to studies that are not 'scientific', so a change in the meaning of the term may have far-reaching practical consequences. Our attempted definition of 'science' in chapter 4 will be – in short – that any topic can become the topic of 'science' as long as it is studied using scientific methodology, and thus that being scientific depends not so much on the subject-matter as on the method used. For a study of Latin, the narrowed modern English concept of science should be avoided.[24] As this change in English is at present less clear-cut for the adjective, one could still speak of 'scientifically obtained knowledge' – if it were not so awkwardly long. So in the remainder of this book, 'science' is to be understood in a broader sense than usually in contemporary English.

As a side-note, it may be pointed out that Antiquity and the Middle Ages were much more aware of the limits to what a word should be able to mean and what it should not than contemporary scholarship (chap. 21 returns to this point). Thus, Isidore (*Etymologiae* I.29.1–5, ed. Lindsay) explains that the inner force of words must be discovered by *etymologia*:

> *Etymologia est origo vocabulorum, cum vis verbi vel nominis per interpretationem colligitur. [...] Cuius cognitio saepe usum necessarium habet in interpretatione sua. Nam dum videris unde ortum est nomen, citius vim eius intellegis. [...] Multa etiam ex diversarum gentium sermone vocantur. Unde et origo eorum vix cernitur.*

23 See chap. 21 below on this topic.
24 Similarly already Kluxen: 'Hier wird man sicher der geschichtlichen und auch der gegenwärtigen Realität besser gerecht, wenn man von Wissenschaft in dem breiten Sinne redet, der im Deutschen üblich ist und der im Englischen etwa durch "higher learning" auszudrücken ist. Sowohl in den Institutionen dieses Bereichs als auch im Bewusstsein der an ihm oder in ihm Tätigen zeigt sich eine gattungsmäßige Einheit, welche die Zusammenfassung in einer Einheit empfiehlt' ('Here one can certainly do more justice to the historical and also the present reality if one speaks of science in a broad sense that is customary in German and that can be expressed in English approximately by "higher learning". Both in the institutions of this field and in the appreciation of those working in or on it, a generic unity is evident, which suggests that it should be summarised under a single unit'; 1981: 277).

> ‘Etymology is the origin of words, as the meaning of a verb or a noun is gathered from its explanation. [...] Its knowledge often has a necessary application in understanding [a word]. For, as you see whence a word stems, you will more easily understand its force. [...] Many [words] are also summoned from the speech of various peoples. Thus also their origin may be hard to discern.’

This same approach to understanding the web of words constituting language by *etymologia* had already been practised by Varro (see chap. 8 §5 below) in his *De lingua latina*. We see a profound difference between antique etymology, which seeks insight into this ‘force of words’, and modern etymology, which strives to find – as Aristotle would put it – the material causes of the phonemes making up a word.[25] A Kuhnian scientific revolution changed ideas about etymology radically in the eighteenth and nineteenth centuries when the notion of sound laws was found.[26] It would seem that both approaches are valid, although the former now appears to lack scientific rigour but might be finding a revival in the theory of semantics and especially that of semantic fields.[27] In order to keep them apart and to avoid confusion, I will distinguish ‘etymology’ from *etymologia*.

Excursus: PIE roots for ‘to know’

§10 All the languages compared in this chapter are Indo-European ones.[28] So it may make sense to diverge briefly and consider what Proto-Indo-European (PIE) words for knowing can be reconstructed. First, a brief look at Sanskrit may be instructive, as this language does not descend from the Greek *Begriffsgemeinschaft*, unlike all the languages considered above. The usual term is *śāstra* (neut.) derived from a root *√śas* (‘instruct, command, punish’; of unclear further kin), so this Indian concept for science derives from a word from the sphere of ‘to instruct’, like the Russian word наука and German *Gelehrsamkeit*, and like Latin *disciplina*. Besides, there is a very general term *vidyā* (fem., ‘knowledge’) from *√vid* (‘know’). There is much Indian literature on what types of *vidyā* should be differentiated. Another word is *vijñāna* (neut., ‘the act of understanding, [...], science, doctrine’), from *√jñā* (‘know, become acquainted with’, thus roughly *cognitio*). The latter two words are prefixed with *vi-* (‘asunder, apart’). In reconstructed PIE, unsurprisingly, there is no word for ‘science’, but there are the fol-

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25 For Isidore’s understanding of *etymologia*, see Ribémont (2001: 39–81); Díaz y Díaz, in *Etymologiae*, ed. Oroz Reta & Marcos Casquero, pp. 186–188.

26 Newly accessible PIE languages (especially Sanskrit) becoming known helped in this respect.

27 See chap. 3 §1 below.

28 Some non-Indo-European languages of science (Arabic and Chinese) will be considered in chap. 22 below.

lowing roots related to 'to know' and 'to learn'. They account for most of the words we have encountered so far:[29]

- **gneh₃* ('get to know'): γιγνώσκω, γνῶσις, *(co)gnosco,* Sanskrit *√jñā, vijñāna.*
- **u̯eid* ('catch sight of'):[30] οἶδα, ἰδεῖν, εἴδησις, *video, wissen, Wissenschaft,* Sanskrit *√vid, vidyā.*
- **h₁eu̯k* ('get used to, learn'): наука, учить.
- **sekH* ('sever: (i) cut, (ii) discern'): *scio, scientia*.
- **steh₂* ('tread somewhere, position oneself'): probably with prefix ἐπι- in ἐπιστήμη.
- **men(s)-dʰeh₁* ('place in the mind'):[31] μανθάνω, μάθημα.

This survey of contemporary meanings of words for science has clearly shown that modern English has strayed from a surprisingly broad consensus in the meanings of *science, szienza, ciencia*, *Wissenschaft,* наука, and επιστήμη, the first three of which, besides, always also exhibit a broader meaning of any kind of 'knowledge'. Below (chap. 10), it will become clear that the semantic consensus identified here goes back to the twelfth-century Latin Aristotelians, who take it over from their Arabic colleagues. To this wide approach Sanskrit *śāstra*, Chinese *kēxué* (科学; see chap. 24 §3), Japanese *gaku* (科学, written with the same characters), or Modern Arabic *ʿilm* could be added.[32] Spanish *ciencia* is the only word we have found that may be on the way to approaching the more restricted English meaning. It is now time to take a step back in time and consider the corresponding Latin and Greek terms.

29 See *LIV* for the forms and meanings.
30 Only these first two words are mentioned in Mallory & Adams (s.v. 'know').
31 From Mallory & Adams (s.v. 'learn'); but this etymology is described as 'unsicher' by Frisk (s.v. μανθάνω).
32 Similarly observed by Staal (2001: 611). But see also chap. 24 below on the difference in what counted as 'science' in these non-European cultures.

2 Terms for 'science' in Greek and Latin

§1 In Antiquity, there is no clear notion of 'science' or *Wissenschaft* as a distinct human activity, but such a concept can be observed developing around some Greek and, later, Latin terms which will be studied in this and the next chapter. Many scientific fields were seen as part of philosophy: there were scientific disciplines (astronomy, geometry, biology, etc.), and there were practical disciplines (*artes*), but there was no term for science *tout court*. Aristotle's ἐπιστήμη and its Latin cognate, *scientia*, are closest to it; they were to be the terms most modern ones descend from. Aristotle already had something like 'knowledge with full understanding' in mind for ἐπιστήμη.[1] People whom we would now address as 'scientists' or *Wissenschaftler* often saw themselves in Antiquity as (natural) philosophers, but also as μαθηματικοί, ἰατροί, σοφισταί, or (ἄνδρες) φυσικοί;[2] what they did could be called ἐπιστήμη, but also φιλοσοφία, τέχνη, θεωρία, or περὶ φύσεως ἱστορία.[3] Modern Greek uses the participle ο επιστήμων ('the knowing one'; δημοτική spelling: ο επιστήμονας) for 'scientist', a term related to ἐπιστήμη.[4] In Latin such people could similarly be called *philosophus, mathematicus, or physicus,* in the Middle Ages also *magister, artifex,* or *artista*, terms that can correspond to our (practical) 'scientist' (but not to our 'artist').[5] Modern Italian uses the compound *lo scientifico* (as does French *le scientifique*), from the Latin (*homo, vir*) *scientificus* ('knowledge-maker' or 'science-performer'), a word first attested in the mid-twelfth century and used quite often from scholastic times onward, but usually as an adjective meaning 'pertaining to science/knowledge, scientific' (see further §3 below).

The next chapter will show that Latin Antiquity was pretty undecided about the best Latin rendering of ἐπιστήμη. Often *disciplina* or *ars* was preferred to *scientia;* only the Latin Aristotle translations from the twelfth century tipped the balance in favour of *scientia*, which, however, could also translate other terms, such as τὸ εἰδέναι or γνῶσις. The translations by Boethius (of the *Organon* without the *Analytica posteriora*) rendered ἐπιστήμη sometimes with *scientia,* sometimes with

1 Burnyeat (1981: 129); more details in chap. 7 §5 below.

2 This last term is especially used by Galen and John Philoponus, as a *TLG* search indicates.

3 See Lloyd (1970: 1, 125).

4 This usage can be seen *in nuce* already in Aristotle, e.g. *Categoriae* 8, 11a33–34: ἐπιστήμονες γὰρ λεγόμεθα τῷ ἔχειν τῶν καθ' ἕκαστα ἐπιστημῶν τινα ('we are called knowledgeable/scientists due to having at our command one of the sciences concerning individuals').

5 The *artista* is *liberalium artium peritus* (Du Cange, s.v.), but the word remained rare (six instances in Corpus Corporum as of October 2018, excepting Raimundus Lullus, who uses it in his own technical jargon all the time); *artifex* is much more common.

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disciplina (see §4). So, it would seem that things only changed for good in the High Middle Ages: from then onward, *scientia* is the usual translation for Aristotle's ἐπιστήμη and thus for Aristotelian 'science' – 'science as a specific approach to knowledge seeking certainty', similar to how we use it today. This becomes obvious in derived terminology such as the *scientificus* or *scientialis notitia* ('scientific knowledge') used by Dietrich of Freiberg around AD 1300.[6] It is also telling that texts about the division of the sciences (*scientiae*) spring up like mushrooms in the twelfth and thirteenth centuries (see chap. 10 §6).

Depending on circumstances, the words ἐπιστήμη/*scientia* in Antiquity can have a much broader range of meanings than 'science' or even *Wissenschaft*. Their basic meaning was 'knowledge' or 'expertness' of whatever kind. Nonetheless, the words ἐπιστήμη and *scientia* also had a clearly defined technical and more narrow meaning, of knowledge gained through 'sound' methodology and often seen as attaining total certainty. The broader use of ἐπιστήμη pre-dates the narrower one, as we shall see. As 'knowledge', and even as 'scientifically ascertained knowledge', ἐπιστήμη first described a state in man (one has or acquires knowledge) and only secondarily developed to mean the acquired knowledge itself ('science' as a body of knowledge). Put differently, the difference is that between the 'subjective' knowledge someone has and 'objective' knowledge that has 'crystallised' into a scientific body of knowledge. Obviously, these two meanings cannot always be easily differentiated, as the former may grow into the latter. Among the languages discussed above, these two meanings still clearly coexist in the French word *science*. In general, it will become clear below (chap. 7 §5) that Aristotle's use of the term ἐπιστήμη was decisive.

It must be kept in mind that as long as there were only a few private (such as Aristotle's *Lyceum*) and no large, state-run institutions where science was practised, the number of scientists necessarily remained very small and they may have been seen as a marginal phenomenon. In Hellenistic times, the rulers in Alexandria and Pergamon funded such schools, which led to significant advances in many fields, but in Roman times and the Early Middle Ages there were no such institutions and (despite some ecclesiastical schools) the advent of actual universities had to wait until the early thirteenth century in the Latin-speaking world. Only then do we get serious discussions about how to call what we now call 'science', and how to keep it apart from 'philosophy' and similar related terms.[7]

In what follows, first the closest equivalents of 'science' in the classical languages, ἐπιστήμη and *scientia*, and their precise meanings, which changed over

6 *De iride* 1.1, ed. Flasch, vol. 4, p. 123.
7 For more details, see the discussion in chap. 8 §3 below.

time, will be studied. The Latin ancestor of the English word 'science', *scientia,* can hardly be studied without taking into account its Greek counterpart, ἐπιστήμη. Indeed, we shall see below (chap. 3) that for many technical terms in this semantic field there is a one-to-one correspondence between one Greek and one Latin word; the Romans took much of their philosophical, scientific, and technical knowledge directly and consciously from the Greeks.

§2 The Latin word *scientia* looks like the perfect loan translation of Greek ἐπιστήμη: both are feminine abstracts of a verb meaning 'to know', and their semantic terrain largely overlaps.[8] This verb, ἐπίσταμαι, is itself well attested in Greek since the earliest times and seems to be derived from ἵστημι ('set, place; stand (middle voice)')[9] and thus to mean originally 'to stand in front of something, to be confronted with it, take heed of it'[10] then also 'to be able to do something'[11] (compare the French *savoir faire quelque chose*). From this, a meaning 'to be convinced of' seems to have been derived, which only from classical times onward becomes 'to know something, especially "scientifically"'. The agent, ὁ ἐπιστήμων, is also attested from as early as the *Iliad* as one 'acquainted with a thing, skilled or versed in it', but not before Aristotle specifically as 'scientifically versed in a thing' (meanings from LSJ, s.v.). In contrast, earlier philosophers such as Heraclitus did not yet use ἐπίσταμαι to denote true knowledge; he used the verb οἶδα[12] instead. In general parlance, these two verbs are often used as synonyms, but Heraclitus uses ἐπίσταμαι for convictions that may equally well be false (D25a LM (Laks and Most) = 57 DK (Diels and Kranz), from Hippolytus IX.10):

> διδάσκαλος δὲ πλείστων Ἡσίοδος· τοῦτον ἐπίστανται πλεῖστα εἰδέναι, ὅστις ἡμέρην καὶ εὐφρόνην οὐκ ἐγίνωσκεν· ἔστι γὰρ ἕν.
> 'Hesiod is the teacher of the many. They are convinced [ἐπίσταμαι] that he knows [οἶδα] the most, he who could not understand [γιγνώσκω] day and night: for they are one and the same.'

8 Hedericus & Pitzger (s.v.) list as meanings for ἐπιστήμη: *1) scientia, 2) peritia, 3) ars, 4) disciplina*. Such related words will be studied in chap. 3 below.
9 Apparently in a psilotic dialect, otherwise there would be a φ not a π; Homer already also uses ἐφίστημι and a corresponding middle voice ἐφίσταμαι as 'to set alongside'. Wackernagel (1895: 20–21) argued that the compound may be very old and go back to a form **epi-sistamai*. At any rate, there are no other obvious candidates for etymologising this word.
10 See Frisk (s.v. ἐπίσταμαι); similarly Beekes (s.v. ἐπίσταμαι). The German *verstehen* is also derived from *stehen*, therefore Heidegger (1979: 192) translates ἐπιστήμη as 'Sich-auf-etwas-Verstehen'.
11 e.g. Herodotus, *Historiae* VIII.89.2, ed. Wilson, vol. 2, p. 744.
12 From this verb is formed a rare noun εἴδησις, which is roughly synonymous with ἐπιστήμη.

This fragment contains three words for 'to know' in a complex relationship. According to LSJ (s.v. γιγνώσκω), οἶδα is used more for facts known by reflection, whereas γιγνώσκω is used for those known by perception or observation. These different terms will be further discussed below. The abstract noun ἐπιστήμη is first met (in its Doric form) as late as the first half of the fifth century BC,[13] in a fragment of Bacchylides (*Epinicia* ode 10, line 38, ed. Maehler, vol. 1, p. 102):

> Μυρίαι δ' ἀνδρῶν ἐπιστᾶμαι πέλονται.
> 'Tens of thousands of skills exist among men.'

Here, then, ἐπιστήμη denotes a general skill; professional activities are intended, as the following lines make clear – what would later rather have been called τέχναι. Thucydides in his *Historiae* (ca. 411 BC) uses the word fourteen times with the same meaning. In contrast to this, the later general meaning of 'factual knowledge' is first attested in Sophocles (e.g. *Oedipus tyrannus* 1115, ed. Lloyd-Jones & Wilson, p. 163; ca. 433 BC), but it is Plato – possibly influenced by his teacher Socrates – who generally uses the word ἐπιστήμη in this sense. Through Plato it became the standard word for 'true knowledge', which in Aristotle was further narrowed down to 'scientific knowledge', thus becoming a technical term in philosophy.[14] As it is only in Plato and Aristotle that the word starts to become used technically, we can focus on these two writers to determine its precise meaning in our context.[15] Plato tends to contrast ἐπιστήμη with mere opinion (δόξα), for example in *Politicus* 301b:

> βασιλέα καλοῦμεν, οὐ διορίζοντες ὀνόματι τὸν μετ' ἐπιστήμης ἢ δόξης κατὰ νόμους μοναρχοῦντα.
> 'we call a monarch "king" and do not distinguish by name one who rules knowledgeably from one who does according to his whim.'

In *Respublica* 422c, ἐπιστήμη comes close to experience (ἐμπειρία), showing that Plato's ἐπιστήμη can still have a very practical leaning:

> ἀλλ' οὐκ οἴει πυκτικῆς πλέον μετέχειν τοὺς πλουσίους ἐπιστήμῃ τε καὶ ἐμπειρίᾳ ἢ πολεμικῆς;
> 'don't you think that the rich have a larger share in the knowledge and practice of boxing than in the art of war?'

In *Theaetetus* the nature of ἐπιστήμη becomes the central topic. Theaetetus successively tries to define it as 'wisdom' (σοφία; 145e) or 'sense perception' (αἴσ-

13 Data from *TLG*. Bacchylides died around 451 BC.
14 Of course, Aristotle and subsequent writers also continue to use the more general meanings.
15 Later uses and some further prehistory are discussed below (chap. 7).

θησις; 151a) but is refuted by Socrates; then he tries 'true opinion' (ἀληθὴς δόξα; 187b), which is further improved to 'true opinion with understanding' (δόξαν ἀληθῆ μετὰ λόγου; 202c) in order to exclude mere skills (τέχναι) that do not strive to understand what they perform. This is followed up below (chap. 7 §4). The *Theaetetus* would shape the use of ἐπιστήμη in the future in requiring both correctness and understanding for 'scientific' knowledge.

Only with Aristotle do specialised sciences become a major preoccupation, whereas his teacher was more focused on general philosophy, dialectics, and how man should behave and live (see chap. 7 §4 below). Nonetheless, Aristotle takes the semantics of the word ἐπιστήμη from Plato, but with him it moves further, now implying more scientifically verifiable knowledge (see chap. 7 §5). For him ἐπιστήμη can be the opposite of mere αἴσθησις (*perceptio*, 'perception'); of δόξα (*opinio,* 'opinion') as knowledge without a basis; or of ἄγνοια (*inscientia,* 'ignorance'), the lack of knowledge altogether. This shows a spectrum of the word very similar to the Latin term *scientia* (see below), which thus seems to have been calqued largely from Aristotelian usage. In principal at least, ἐπιστήμη is also distinguished from the more practical τέχνη (*ars,* 'craft, practical science'), but Aristotle does not always stick to this distinction himself.[16] Aristotle's ἐπιστήμη has explanatory force and takes recourse to ἀρχαί (*principia*, 'principles, beginnings') and αἰτίαι (*causae*, 'causes'), thus leading the way for deductive science from (axiomatic) first principles. But for Aristotle the word ἐπιστήμη can mean any kind of methodologically gained, certain, 'theoretical' knowledge based on a rational or logical foundation; it may be gained by induction as well as by deduction.[17] Aristotle is the first author we know of who speaks of 'sciences' in the plural, thus of various scientific fields, for instance in *Metaphysica* (E1, 1026a19), where first philosophy (metaphysics/theology), mathematics, and physics are said to be ἐπιστῆμαι. The corresponding verb ἐπίσταμαι is often used by Aristotle for more 'scientific' knowing than οἶδα, which can be any kind of knowing: διὰ τὸ εἰδέναι τὸ ἐπίστασθαι ἐδίωκον ('in order to know I pursued science'; *Metaphysica* A2, 982b)[18] – thus reversing the usage observed in Heraclitus above.

There were specialised 'scientists' (in the Aristotelian meaning of 'science' just described) in the wake of Aristotle at his school[19] and in Hellenistic times in general. In Roman times, however, few people seem to have tried to follow

16 See Bonitz (s.v. ἐπιστήμη).

17 As detailed e.g. in *Ethica Nicomachea* VI.3–4, 1139b15–1140a23, quoted in chap. 3 §4 below.

18 LSJ (s.v. ἐπίσταμαι): 'but sts. [sometimes] εἰδέναι is general, ἐπίστασθαι being confined to scientific knowledge'.

19 Besides the well-known Theophrastus, the founder of botany, their rather scant fragments were collected by Wehrli (1944–1978). For more on some of them, see chap. 7 §6 below.

Aristotle's strict ideals of what can pass as certain science.[20] But at least something akin to a linguistically palpable consciousness for scientific methodology seems to have remained intact: some authors use derived words such as ἐπιστημονικώτερος[21] ('more scientific') or ἐπιστημονικῶς ('scientifically'). The adjectival form of the latter is already quite common in Aristotle (19 times), but the adverb occurs only once (*Topica* II.9, 114b10), as 'knowingly', not 'scientifically'. This adverb (in the latter sense) can be seen as an indicator that a clear concept of 'science' exists for the author using it. It is quite common in Galen (27 times, according to *TLG* as of December 2017) and among Aristotelian commentators such as Alexander of Aphrodisias (6), Simplicius (19), or Philoponus (20). Some of the later Greek authors use ἐπιστήμη clearly as 'scientific knowledge' that is 'certain and unmoved by persuasion' (cf. Ptolemy, quoted in chap. 7 below).

§3 The first time the word *scientia* is found in extant Latin literature is in the anonymous *Rhetorica ad Herennium* (ca. 86–82 BC),[22] but it was clearly not new then and may have been used for some time before in texts that have not come down to us. The Auctor ad Herennium uses it five times.[23] In chapter 12 we learn that *imprudentia* ('want of foresight or knowledge') can be an opposite of *scientia*,[24] and that the latter can thus be close in meaning to *prudentia* ('wisdom'). In II.44 it becomes clear that *ars*, *scientia,* and *studium* are closely related terms for technical – rhetorical, scientific, or scholarly – occupations, and in IV.37 that

20 See Thorndike (1923–1958: vol. 1), showing the 'magical' and uncritical thinking of even famous scholarly authors such as Pliny and Galen. See further chap. 7 below.

21 Cf. Proclus, *In Euclidem* prol. 2, ed. Friedlein, p. 66, on Theaetetus, who made geometry 'more scientific'.

22 Dating from *Lexikon der antiken Literatur* (s.v. *Rhetorica ad Herennium*). Unfortunately, the *TLL* article on *scientia* has not yet been published.

23 Such search data always stems from Corpus Corporum (http://www.mlat.uzh.ch), where further information, such as the edition used, can be found. Lemmatised queries are possible.

24 Here is the wording of the five passages: *Spes perficiendi ecqua fuerit, spectabitur hoc modo: si, quae supra dicta sunt signa, concurrent, si praeterea ex altera parte uires, pecunia, consilium, scientia, apparatio uidebitur esse, ex altera parte inbecillitas, inopia, stultitia, inprudentia, inapparatio demonstrabitur fuisse; qua re scire potuerit, utrum diffidendum an confidendum fuerit* (II.7, ed. Achard, p. 37). *Item uitiosum est artem aut scientiam aut studium quodpiam uituperare propter eorum uitia, qui in eo studio sunt: ueluti qui rhetoricam uituperant propter alicuius oratoris uituperandam uitam* (II.44, p. 76). *Dicitur item prudentia scientia cuiusdam artificii* (III.3, p. 89). *Item, si quo pacto poterimus, quam is, qui contra dicet, iustitiam uocabit, nos demonstrabimus ignauiam esse et inertiam, ac prauam liberalitatem; quam prudentiam appellarit, ineptam et garrulam et odiosam scientiam esse dicemus* (III.6, p. 92). *Nihil Numantinis uires corporis auxiliatae sunt, nihil Kartaginiensibus scientia rei militaris adiumento fuit, nihil Corinthis erudita calliditas praesidii tulit, nihil Fregellanis morum et sermonis societas opitulata est* (IV.37, p. 175).

there is a branch of learning called ‘military prowess or science’, which, however, was of no avail to the Carthaginians against Rome. In IV.53 *scientia* is found together with *certus*, a combination that will become important and frequent (see §4 below).

The word is next found in Varro’s *De lingua latina*.[25] In one of its three occurrences there, insight into its meaning is gained as Varro contrasts it to *opinio*.[26] So the word seems from its very beginning to take on the rôle of its Greek counterpart ἐπιστήμη and its opposite δόξα. Finally, the word becomes very frequent with Cicero, who often clearly uses it as a Latin equivalent to Greek ἐπιστήμη, although more frequently *sensu lato* as general ‘knowledge’.

Better insight into the many shades of meaning of *scientia* already present in Antiquity can be gained from the entry in the Lewis & Short dictionary (distinct meanings underlined):

> **scĭentĭa**, ae, *f.* (plur. only Vitr. 1, 1, 18; 3, praef. 1) [sciens], a knowing or being skilled in any thing, knowledge, science, skill, expertness, = *cognitio*, *eruditio* (freq. and class.). *Absol.*: *aut scire istarum rerum nihil, aut, etiamsi maxime sciemus, nec meliores ob eam scientiam nec beatiores esse possumus,* Cic. Rep. 1,19,32 [...] *etsi ars, cum eā non utare, scientiā tamen ipsā teneri potest,* in theory, theoretically, Cic. Rep. 1,2,2; so (opp. *ars*) id. Fin. 5,9,26; [...] *cum tanta sit celeritas animorum ... tot artes tantae scientiae, tot inventa,* requiring so great knowledge (scientiae is *gen. sing.*), Cic. Sen. 21,78 (dub.; B. and K. bracket the words *tantae scientiae*); cf.: *physica ipsa et mathematica scientiae sunt eorum, qui,* etc., Cic. de Or. 1,14,61.— *Plur.*: disciplinarum scientiae, Vitr. 3, praef. §1. With *gen. obj.*: [...] *sine regionum terrestrium aut maritimarum scientiā,* Cic. de Or. 1, 14, 60: [...] With *in* or *de* and abl. (rare): *scientia in legibus interpretandis,* Cic. Phil. 9,5,10: *in affectibus omnis generis movendis,* Quint. 10,2,27: *cujus scientiam de omnibus constat fuisse, ejus ignoratio de aliquo purgatio debet videri*, Cic. Sull. 13,39.

If we compare this extract from the German dictionary by Georges (s.v.), these basic meanings are found in somewhat greater detail. Georges rightly stresses the difference between a broader and a narrower meaning:

> **scientia**, ae, f. (sciens), das Wissen, die Kenntnis, die Kunde, die Wissenschaft, I) im allg. (Ggstz. *ignoratio*): *regionum*, Cic.: *futurorum malorum*, [...] II) insbesondere, das gründliche Wissen, die gründliche Kenntnis, Wissenschaft, das Verstehen einer Sache, die Vertrautheit mit einer Sache, die Einsicht, die Geschicklichkeit in etwas, [...] Wissenszweige, Vitr. 9,7(6),3, *disciplinarum scientiae* u. *scientiae artificiorum*, Kenntnisse in den verschiedenen Zweigen der

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25 This work was written as late as between 47 and 45 BC and was dedicated to Cicero (*Lexikon der antiken Literatur,* s.v. *De lingua latina*), but the author, born in 116 BC and living a very long life, is likely to have used the word before Cicero, who was eleven years younger.

26 *De lingua latina* V.1(8), ed. Goetz & Schoell, p. 6; the text may be corrupt, but the letters under debate have no influence on the contrast to *opinio*.

> Kunst, Vitr. 1,1,17, *scientiae artium variarum,* Augustin. de civ. dei 7,30: *scientiarum artes* [...] b) v. philos. gründlichem Wissen (Ggstz. *inscientia*).

This same important point about the broader and narrower meanings is also made in Gaffiot’s dictionary (s.v.) as (i) *connaissance* versus (ii) *connaissance scientifique, savoir théorique, science*. Therefore, the meaning of the word *scientia* can in Antiquity be broadly classed as (i) ‘expertness, skill’, synonymous with *cognitio*, *eruditio* and the opposite of *ignoratio*; and (ii) ‘knowledge’ as the opposite of *inscientia* (‘ignorance’), with a subspecies of ‘certain knowledge’, the semantic precursor of ‘science’. In contrast to *ars*, it denotes a more ‘theoretical’ activity aiming at the fullest possible certainty. In the plural it denotes ‘branches of knowledge or science’ – what will become scientific disciplines. This usage is already common in Aristotle as ἐπιστῆμαι. For Latin, modern Ciceronians have long contended that *scientia* is a *singulare tantum* in ‘good’ Classical Latin.[27] All these meanings, even the plural, it would seem, are already present in Cicero. Thus, even in the first century BC, *scientia* exhibits a range of meanings, from the mere act of knowing something or how to do something to organised, theoretical scientific knowledge. It is interesting to note in passing that for *scientia*, all three classical dictionaries quote mostly passages from Cicero, who was especially involved in importing Greek modes of thinking into Latin[28] and who among writers whose works have survived uses the word by far the most frequently in the first century BC (243 times in Corpus Corporum, or 0.22‰ of all the words he used).

As is to be expected in the ‘fixed’[29] language of Latin, this wide range of meanings is maintained through the Middle Ages into modernity, to the authors

27 The typical passages for ‘sciences’ in the plural in Cicero are (underlined) *De senectute* 21, ed. Mueller, p. 159 (*cum tanta celeritas animorum sit, tanta memoria praeteritorum futurorumque prudentia, tot artes, tantae scientiae, tot inventa, non posse eam naturam, quae res eas contineat, esse mortalem*) and *De oratore* I.14(61), ed. Kumaniecki, p. 25 (*physica ista ipsa ‹et› quae paulo ante mathematica‹e› et ceterarum artium propria posuisti, scientiae sunt eorum qui illa profitentur, illustrari autem oratione si quis istas ipsas artis velit, ad oratoris ei confugiendum est facultatem*). Krebs (1843: 709) thought a plural of *scientia* ‘unlateinisch’ and explained such passages away, the former, as is also done by Lewis & Short, as a genitive singular. Whether Cicero used this plural is of little concern for us. Times after him quickly did (already Vitruvius, *De architectura* IX.6, ed. Fensterbusch, p. 438), and among Christians the plural becomes very common indeed.

28 Cf. passages in chap. 8 below.

29 On this term, see chap. 16 §1 below. This is to be expected, as Post-Classical Latin – in contrast to ‘living languages’ – never discarded anything of its grammar and lexicon, but it did allow in novelty to some degree. That novelty was kept in check by language purists of all periods, but especially so by Ciceronian humanists, as we shall see in chap. 12.

of the Scientific Revolution and thence into the Romance languages and English, which, as we have seen, has only quite recently tended to restrict usage to a new, even narrower meaning of 'natural sciences'. German did not borrow this word but translated it by splitting it into smaller semantic units: from *Wissen* (approximately 'act of knowing') to *Kenntnis* ('knowledge') and *Erkenntnis* ('insight'), to *Wissensbereich, Wissenschaft* ('science', as described above), and *Naturwissenschaft* ('natural science').

In order to better understand the semantic range of Latin *scientia,* a list of adjectives occurring right before or after it was generated. Among the 1,409 hits in Corpus Corporum (as of May 2018), the most common ones were[30] *bona* (155), *divina* (73), *spiritalis* (55), *omnis* (50), *abscondita* (47), *tanta* (46), *vera* (46), *civilis* (37), *perfecta* (34), *mala* (30), *futura* (29), *magna* (24), *certa* (21), *plena* (20), *naturalis* (18), *praedita* (17), *caelestis* (16), *humana* (16), *tota* (14), *profunda* (13), *prophetica* (13), *sola* (13), *nulla* (12), *summa* (11), *utilis* (10), *scibilis* (9).[31] The underlined words will mostly stem from Christian usage in relation to 'divine knowledge', for instance in the Genesis tree of *scientia boni et mali*. Among the others, veracity and certainty definitely play the main rôle (*omnis*, *vera, perfecta, magna, certa, plena, tota, profunda, summa*), while some anticipate main characteristics of modern science: *naturalis, utilis, scibilis*. The following terms derived from *scientia* were found in Corpus Corporum and in the dictionaries by Georges, Niermeyer, and Du Cange: *scientialis, scientialiter, scientiola* (depreciative used once by Augustine), *scientiatus, scientiose*. As already mentioned, in scholastic times we also encounter *scientificus* (Schütz, s.v.). They are few in number and all of them are rare, much rarer than their Greek counterparts. Latin's general reluctance to accept new words will be discussed further below (chap. 22). The rare adjective *scientialis* is first attested in Mamertus Claudianus (later fifth century).[32] The derived compound *scientificus* has an unusual and late history.[33] It is first attested in a translation of Aristotle's *Analytica posteriora*

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30 The greatest number of texts are from between AD 300 and 1200.

31 This feature is still experimental, and the results may not be fully accurate, as the adjectives were not required to be in the same case and number as *scientia*.

32 *De statu animae* II.5, ed. Engelbrecht, p. 117.

33 See the detailed study in *OED* (s.v. 'scientific'): 'first attested in the translation of a1160, ascribed to an otherwise unknown Joannes, of the *Posterior Analytics* of Aristotle, where it renders Ancient Greek *ἐπιστημονικός* "relating to knowledge" (see epistemonical adj.). At 1. 2 (71b18), Joannes followed the earlier translation by James of Venice, rendering *συλλογισμὸν ἐπιστημονικόν* "a syllogism having to do with knowledge" as *sillogismum facientem scire* "a syllogism producing knowledge"; [...] Joannes reworded this to *scientificae demonstrationes*, "demonstrations producing knowledge", and this form of words was taken over by William of Moerbeke in his revision of James's translation.'

from the mid-twelfth century,[34] where it literally means *faciens scire*. Very soon it gains acceptance in the wider sense as a synonym for *scientialis;* around 1167, Johannes Sarracenus already uses it in his translation of Dionysius Areopagita, *De caelesti hierarchia* (ed. Chevallier, p. 851); Thomas Aquinas uses the word forty times, and in the following centuries it becomes common, often approximating in meaning our 'scientific', which derives from it. It seems that the lack of such a term was felt from the twelfth century onward, confirming that the awareness of a concept 'science' had definitely been established by then. Some diachronic frequency numbers of the lemma *scientia* are presented below (§10). But first, some Latin definitions.

A sketch of later developments

§4 In his translations of the Aristotelian *Organon*, Boethius sometimes used *scientia* for ἐπιστήμη, sometimes *disciplina*.[35] In the PL editions of all of his works, *scientia* occurs 131 times (0.33‰).[36] It will be interesting to consider some later definitions of *scientia,* although they cannot be more than a few spotlights on a historical development that will be traced chronologically in part 2 of this book. In his very influential synthesis of antique erudition, Isidore of Seville (*Etymologiae* II.24.1–2, ed. Marshall, p. 101) writes:

> *Philosophia est rerum humanarum diuinarumque cognitio cum studio bene uiuendi coniuncta. Haec duabus ex rebus constare uidetur, scientia et opinatione. Scientia est, cum res aliqua certa ratione percipitur; opinatio autem, cum adhuc incerta res latet et nulla ratione firma uidetur, utputa sol utrumne tantus quantus uidetur, an maior sit quam omnis terra: [...].*[37]
>
> 'Philosophy is becoming acquainted with human and divine matters joined to the pursuit of living well. It seems to consist of two parts: certain knowledge [*scientia*] and conjecture. It is certain knowledge if something is perceived by certain reason, but conjecture if the matter

34 Older dictionaries wrongly claim, following PL, that the word occurs in Boethius. Some recent writers, such as Wootton (2015: 29), still mistakenly follow them.

35 See the indexes to *Aristoteles Latinus*. In *Topica* and *Analytica priora*, Boethius prefers *disciplina*. In the *Spohistici elenchi*, he uses sometimes *disciplina* (more often), sometimes *scientia*.

36 Many of them are wrongly attributed to Boethius, so this number must be taken as an approximation.

37 The example of the size of the Sun is taken from Lactantius, *Institutiones* III.3.4, as Marshall points out. It is not very fortunate, as it had for a long time been common knowledge that the Sun is very large. Lactantius (see Gleede 2021: section 3.1) was the only one of the Latin early Church writers who believed in a flat Earth, and was generally ignorant of and not interested in natural science.

remains as yet uncertain and no solid reasoning is visible yet, e.g. whether the Sun is as big as it seems, or bigger than the entire Earth [further examples follow].'

So, here *scientia* is more a form of certain knowledge in general than a corpus of scientific disciplines. In fact, this usage remains the more common one prior to the twelfth century; *disciplina* is often used in the sense of 'scientific disciplines', as will be seen below. Things change with the twelfth-century translations: from now on, *scientia* becomes the standard term for Aristotelian ἐπιστήμη and quickly approaches what we found to be the common European meaning of 'science' (chap. 1). This development will be detailed below in the diachronic part of the book (chap. 10 §6). The crucial events were the translations of Aristotle's *Analytica posteriora* (the only part of his logical writings that had not been translated by Boethius) and al-Fārābī's *De scientiis*. The former text deals extensively with the way (Aristotelian) science is meant to work.[38] As a consequence, authors for the first time make conscious divisions of different *scientiae* and wonder about differing levels of certainty of scientific knowledge. For instance, Robert Grosseteste, who wrote the first surviving commentary on the *Analytica posteriora* (ca. 1220), states (*In Analyticam posterioram* I.2, ed. Rossi, p. 99):

Sed non lateat nos quod scire dicitur communiter et proprie et magis et maxime.
'But it should not remain hidden that "to know" is said commonly, properly, more properly, and most properly.'

Grosseteste then makes clear that he means to differentiate between haphazard knowledge, the natural sciences, the mathematical sciences, and knowledge of the first cause, God.[39] Although he uses *scientia* as a mere abstract equivalent to

38 But see chap. 7 §5 below. Giard (2009) describes important stages in the semantic development of *scientia*, rightly stressing the importance of the translations of Aristotle's *Analytica posteriora*.

39 Compare Aristotle, *Metaphysica* E1, 1026a19, mentioned above (§2). Grosseteste further elaborates: *Est enim scientia communiter veritatis comprehensio, et sic scitur contingentia erratica; et dicitur scientia proprie comprehensio veritatis eorum que semper vel frequentius uno modo se habent, et sic sciuntur naturalia [...]. Dicitur etiam scientia magis proprie comprehensio veritatis eorum que semper uno modo se habent, et sic sciuntur in mathematicis tam principia quam conclusiones [...] manifestum est quod maxime proprie dicitur scire comprehensio eius quod inmutabiliter est per comprehensionem eius a quo illud habet esse inmutabile et hoc est per comprehensionem cause inmutabilis in essendo et in causando* ('Science in general is any comprehension of truth, thus erratic contingencies are known. Science properly speaking is the comprehension of the truth of those things that behave always or for the most part equally, thus matters concerning nature are known [...]. More properly, science is the comprehension of the truth of those things that always behave equally, thus in mathematics both principles and conclusions are known [...]. It is clear that most

scire, the last three forms are clearly intended as 'scientific knowledge'. In the same period, Gerard of Cremona (ca. 1114–1187) translated Avicenna's (ca. 980–1037) *Qānūn* into Latin, which was to become very important for European medicine. At the beginning, Avicenna discusses whether medicine is a science (*ʿilm*) and decides that it has a theoretical and a practical part. Gerard renders the two options as *scientia scientialis* and *scientia operativa* (Avicenna, *Liber canonis* 1.1.1, 1507 edition, fol. 1ra). He also calls the first *theoretica;* it is *ad sciendum principia* ('to know the principles'). A little before, he uses the word *ars* as a synonym for *scientia*. The term *scientia* (*scientialis*) here clearly stands for something very close to our modern 'science'; it is a translation of *ʿilm,* which itself had translated Aristotle's ἐπιστήμη (see §6).

In the scholastic university age, this Aristotelian *scientia* becomes the usual term for 'science'; we can take the usage of Thomas Aquinas as an example: he often reflects on what science is, and he is heavily indebted to Aristotle for it, especially and unsurprisingly in his *Expositio libri posteriorum* (Leonina edition; written ca. 1270), which he knew both through the translation by James of Venice and through William of Moerbeke's revision of it; *scientia* is set against *opinio* (I.44, p. 166; commenting 88b30), it is *universalis* and is applied *per necessaria* (p. 167; commenting 88b31). It is reached through proof and brings certainty (p. 167; commenting 88b32):[40]

> *scientia inportat certitudinem cognitionis per demonstrationem acquisitam.*
> 'science means certainty of cognisance by means of adduced demonstration.'

It uses syllogisms, and its content cannot be different than the way it is (I.4, p. 17; commenting 71b17):

> *Demonstrationem autem dico sillogismum sciencialem, id est facientem scire.*
> 'I call "proof" the scientific syllogism, i.e. one that produces knowing.'

Further, he sees *scientia* as the 'essence' (*ratio*) of all things that may be known;[41] the 'scientist' becomes 'assimilated' to his topic by it.[42] Its sources are twofold:

properly knowing something is the comprehension of what is immutable about it, by comprehending from whence it has its immutable being, and this means by comprehending its immutable cause, both for its being and having been caused'; *In Analyticam posterioram* I.2, ed. Rossi, p. 99).

40 Very similarly also Thomas's teacher Albert the Great, *De homine*, cap. *De anima rationali,* 1.1 *Quid sit opinio,* ed. Anzulewicz, vol. 27.2, p. 393, quoting *Analytica posteriora*.

41 *Summa theologiae* IIa IIae, q. 55, a. 3, concl., Leonina edition, vol. 8, p. 400: *Scientia est recta ratio scibilium* ('Science is the correct essence of the knowable').

42 *Summa theologiae* Ia, q. 14, a. 2, arg. 2, vol. 4, p. 168: *Scientia est assimilatio scientis ad rem scitam* ('Science is the assimilation of the knower to the known thing').

it is acquired through study of authoritative texts and through direct discovery.[43]

As another example, we can consider the grammarian Radulphus Brito (ca. 1270–1320), who tells the reader what he takes *scientia* to be (q. 1, ed. Enders & Pinborg, p. 90), again in the wake of the *Analytica posteriora*:

> *cognitio proprietatum alicuius scibilis de ipso per causas et principia illius, talis habitus est scientia. [...] Et potest breviter ratio sic sumi: Scientia est habitus conclusionis per demonstrationem acquisitus.*
> ‘becoming acquainted with something knowable through its own causes and its principles, such a state is science. [...] And in short, this argument can be subsumed thus: science is the state of concluding acquired through proof.’

In contrast to natural science, grammar is one of the *scientiae sermocinales* (q. 2, pp. 93–95),[44] which broadly correspond to the mediaeval *artes* of the *trivium,* but is taken by Radulphus not as a mere practical and auxiliary discipline but as one that can be studied theoretically in its own right, which is why he emphasises its character as a *scientia*. It is out of such an approach that the human sciences or *Geisteswissenschaften* will develop. These approaches distilled from Aristotle by these early scholastic writers are repeated over and over again in scholastic and neo-scholastic texts up to the twentieth century – still, for example, in Carolus Boyer’s *Cursus philosophiae* (1952).

In conclusion, we can say that *scientia* means ‘knowledge’ in general but also κατ’ ἐξοχήν, the most certain knowledge available to man, thus ‘science’. This broad spectrum of types of knowledge only acquires a clear semantic nucleus of ‘science’ in Latin as late as in the twelfth century. This does not mean that earlier Latin authors did not know or practise ‘science’, but they did often use other terms for it (as the next chapter will show). The following later definitions show that the term was by then clearly consolidated; indeed, it was to pass into the Romance languages and English from this stage of Latin.

Early modern usage

§5 It will become obvious in part 2 of this book that the heydays of scientific production in Latin are in early modern or ‘Neo-Latin’ times. So, in order to complement the studies on the vernacular words for *scientia* (chap. 1 above), it will now

43 *Summa contra gentiles* II.75, Leonina edition, vol. 13, p. 475: *Et ideo scientia adquiritur dupliciter: et sine doctrina, per inventionem; et per doctrinam* (‘And thus science is acquired in two ways: both without teaching, by invention; and by teaching’).

44 On this *scientia vel philosophia sermocinalis*, see Ramminger (s.v. *sermocinalis*; 11 March 2019).

be considered how the Latin word was used in early modern times. As there are no large modern dictionaries of Neo-Latin, some early modern Latin–Latin encyclopaedias were consulted to find out how their authors understood the concept.[45] The Calepinus encyclopaedia, which was founded by the Augustinian friar Ambrosius Calepinus (ca. 1440–1510), reiterates the Aristotelian approach to what *scientia* is in its 1553 edition (s.v.):

> *Certa rei alicuius per causam cognitio, ἐπιστήμη. Philosophi definiunt esse habitum, una vel pluribus demonstrationibus acquisitum, quo certo scimus rem aliter se non posse habere.*
> 'The certain knowledge of something through its cause, ἐπιστήμη. The philosophers define it as a state, acquired through one or several proofs, by which we know that a thing cannot be otherwise.'

Further down in the same entry, Cicero is quoted for this meaning; its opposite is named as *inscientia*, an opposite we have not met above in classical dictionaries. The same entry is found in the *Dictionarium hexaglottum* version (Basileae, 1568). In contrast, the first edition (Rhegium Lingobardum, 1502) had no entry for *scientia* at all, the second ([Venice], 1506) only a very short one, telling the reader how the word is formed (*a participio sciens fit*), that *inscientia* is its opposite, and: *Est autem scientia qua aliquid scitur* ('*Scientia* is through which something is known'; s.v.), thus defining the wider meaning of *scientia* as 'knowledge'. The Aristotelian insistence on causes and that science is a *habitus* recur in Johannes-Henricus Alstedius, *Encyclopaedia septem tomis distincta* (Herbonae Nassoviorum, 1630), vol. 1, p. 56:

> *Scientia est habitus contemplativus, quo quis inclinatur ad assentiendum conclusionibus necessariis per proprias, sive proximas causas, non autem primas.*
> 'Science is a contemplative state by which someone is led to agree with necessary conclusions through proper, that is proximate and not first,[46] causes.'

In the second half of the seventeenth century, the time of the Scientific Revolution (see chap. 13 below), the nature of *scientia* becomes even more central. Henning Volckmar in his *Dictionarium philosophicum* (Francofurti, 1675), pp. 602–607, distinguishes five meanings of the word (*est vocabulum πολύσημον*):

> *(1.) opponitur ignorantiae, qua ratione etiam fidem et opinionem includit. [...] (2.) Contradistinguitur fidei, cujus objectum est πιστόν sive credibile; scientiae autem objectum est ἐπιστητόν sive scibile. [...] (3.) Distinguitur ab opinione, [...] scientia verò est firma, certa et infallibilis,*

45 See Considine (2014). In general, see König (2013).

46 This rightly excludes 'explanations' by first causes, such as 'it is so because God willed it', from science.

> *adeoque cum animi certitudine conjuncta notitia et cognitio. (4.) Aequipollet toti disciplinae scientificae sive totali habitui theoretico conclusionum de objecto determinato formatarum [...]. (5.) Notat habitum partialem sive notitiam unius conclusionis necessariae certam et infallibilem.*
> '(i) [Science] is opposed to ignorance, which is why it also includes faith and opinion. [...] (ii) It is distinguished from Faith, whose subject are things that are πιστόν, or believable; in contrast, the subject of science are things that are ἐπιστητόν, or knowable. [...] (iii) It is distinguished from opinion, [...] indeed, *scientia* is firm, certain, and infallible taking-notice or cognisance that is thus coupled with the mind's certainty. (iv) It is equivalent to all scientific disciplines, or to the total theoretical state of proofs formed about a certain subject [...]. (v) It indicates a partial state or a single act of taking notice of one necessary conclusion which is certain and infallible.'

The meaning of 'science' is covered by (iv): again, certainty and proof are the central aspects of science. The 'subjective' meaning (v) is clearly kept apart from the 'objective' one (iv). In his *Lexicon rationale* (Rotterodami, 1692), Étienne Chauvin offers a very long entry (nearly five columns) which defines, among other things:

> *Scientia latiore significatu sumitur pro omni cogitatione certâ et evidenti; sive ea ex ratiocinatio, sive ex sensuum experientiâ ducatur, dummodò ex objectis ipsis ea cognitio sit profecta: nam si aliorum testimonio nitatur, tum scientiae nomen vix sibi assumet. [...] hâcque ratione scientiam ab ignoratione, suspicione et opinione distinxit Tullius, [...].*
> *Strictius et magis propriè scientia accipitur pro cognitione certâ et evidenti rei necessariae, per propriam causam.*
> 'Scientia is used in the wider sense for every certain and evident thought; be it guided by ratiocination or sense experience, provided that this cognisance be achieved out of the objects themselves. For if it rests on others' testimony, it will hardly bear the name *scientia*. [...] for this reason Cicero distinguished *scientia* from ignorance, suspicion, and opinion, [...].
> In a stricter and more proper way *scientia* is used for certain and evident cognisance of something necessary, through its own causes.'

Thus, this author further differentiated the science of things that are necessarily as they are (especially mathematics) from science that is certain but not necessary. Similarly, but much more briefly, Rudolph Goclenius in his *Lexicon philosophicum* (Francofurti, 1613), pp. 1009–1010, had stated half a century earlier:

> *Scientia duobus modis accipitur: Proprie pro eo habitu, quem per demonstrationem acquirimus. [...] Improprie accipitur pro quibusuis aliis habitibus intellectiuis.*
> 'The term *scientia* is applied in two ways: properly to that state which we acquire through proof. [...] Improperly it is applied to any other theoretical[47] state.'

47 *Intellectivus* is a common rendering of Greek θεωρητικός.

And in 1751, Christian Wolff in his *Philosophia moralis sive ethica,* vol. 1, §402, gave a similar definition:

> *Scientia est habitus demonstrandi, quod affirmamus, vel negamus.*
> 'Science is a state of proving what we agree to, what we reject.'

In his dictionary (*Lexicon totius latinitatis*, Lipsiae, 1775; s.v. *scientia*), which is already more a philological enterprise and no longer really an encyclopaedia, Aegidius Forcellini distinguishes 'subjective' and 'objective' *scientia* in a long and informative entry. The former, as a single *actus sciendi*, corresponds largely to the wider sense (i) mentioned by, among others, Chauvin above; the latter is described thus:

> *Objective, uti ajunt,*[48] *est doctrina, eruditio, facultas in aliqua arte liberali ([...] Germ. Wissenschaft, Gelehrsamkeit; Angl. erudition, learning). [...]*
> *Ita differt scientia a notitia et cognitione, ut haec sit quodammodo exterior, illa intima rei notio, aut haec rei simplex perceptio, illa penitior ac certior notio seu intelligentia.*
> 'Objectively, as people are wont to say, it [*scientia*] is doctrine, erudition, ability in some liberal art ([...] German: *Wissenschaft, Gelehrsamkeit*; English "erudition", "learning"). [...]
> Thus science differs from knowledge or cognisance, as the latter are in a certain way an exterior knowledge of something, but the former an intimate one; alternatively the latter the simple perception of something, the former more thorough and certain knowledge or understanding.'

Although the approach is here clearly more descriptive and philological, the emphasis is still on certainty, but also on depth of understanding. The more cautious approach, which demands more certain knowledge and not absolute certainty, should be noted; it is a point modern theoreticians of science will certainly agree with. This narrower sense of *scientia* is still significantly broader than that of contemporary English 'science', but seems by and large equivalent to German *Wissenschaft*, Russian наука, and Modern Greek επιστήμη.

Some extreme Ciceronians insisted that *scientia* should only be used as 'subjective' knowledge, i.e. *my* knowing of something, whereas only *disciplina* and *doctrina* (see chap. 3 §§3, 8 below) should be used for 'objective' bodies of knowledge. Heusingerus (*Emendationum*, p. 428) writes:

> *SCIENTIA non dicitur de* doctrina, artium praeceptis *et* disciplina*, sed de earum* peritia *et percepta* cognitione. *Non sunt igitur vulgaria haec Latina,* amat scientias, patronus magister et doctor scientiarum.

48 Forcellini uses the Latin terms *subjective* and *objective* like the modern vernaculars, unlike usual Latin practice. He acknowledges this by adding *uti ajunt*.

> '*Scientia* does not refer to doctrine, rules of arts, or [scientific] discipline, but to skill in them and the understanding gained. These vulgar expressions are therefore not Latin: "he loves the sciences", "patron, master, or doctor of the sciences".'

We have seen (§1 above) that even Cicero may have used such barbarian non-Latin from time to time, even though Krebs claimed that the word *scientia* has no plural. These 'antibarbarus' authors in the eighteenth and nineteenth centuries may be seen as unconscious language engineers striving to construct an ideal Latin language (see chap. 14 §11) that they projected back to the time of Latin's 'Golden' Age. In this and their near-religious fervour, they can be seen as typical products of a Protestantism that strove to return to a golden past *in illo tempore*. In practical life, they were ignored: *scientia* was and remained the normal Latin term for 'science', including in plural.

Possibly the last author who defines *scientia* in Latin is Springhetti in 1967; this author, however, again stands very clearly in a Thomistic scholastic tradition and seems to be considering modern science much less (if at all) than scholastic theology. Even so, in its broad distinctions between different meanings, the following quotation can summarise much of the discussion so far (*Latinitas fontium,* p. 128):

> scientia = *1) scientifica cognitio (proprie dicta), distincta ab ars*, intellectus, sapientia, prudentia; *namque* scientia *importat rectam cognitionem* circa conclusiones; intellectus *importat rectam cognitionem* circa principia; sapientia *importat rectam cognitionem* circa altissimas causas *(divinas);* ars *importat rectam rectitudinem rationis* circa contingentia *h.e.* circa factibilia *h.e. circa ea quae aguntur in exteriorem materiam, ut secare: in his dirigit ars, addita tamen ratione, quae principia in conclusiones deducit;* prudentia *importat rectitudinem rationis* circa contingentia *seu* agibilia *seu* actus qui sunt in operante, *ut amare, odisse, etc.: pertinet ad* actus morales, *quos dirigit prudentia; 2) lato sensu: cognitio seu scientia intellectualis, certa et evidens, cui opponitur* fides *et* opinio, ignorantia *et* nescientia*; 3)* donum *scientiae; 4) donum charismaticum*.
> '*Scientia* means: (i) scientific cognisance (properly speaking), which is different from art, intuition, wisdom, prudence, for science means correct knowledge with respect to conclusions; intuition means correct knowledge with respect to principles; wisdom means correct knowledge with respect to the highest (divine) causes; art means correct knowledge with respect to contingent (non-necessary) matters, i.e. with respect to practical things, i.e. with respect to what is done in outward matter, such as cutting: in these matters, art leads the way, although reason is also contained in them: it leads the principles to conclusions; prudence means the correctness of reason with respect to contingent matters or things done by us or acts which are in the doer, like loving, hating, etc.: it belongs to moral action, which directs prudence. (ii) In the wide sense [*scientia* means] intellectual cognisance or science, which is certain and evident, to which belief and opinion, ignorance and nescience[49] are opposed. (iii) The gift of science. (iv) The charismatic gift.'

49 Latin *nescientia* is a rare word (95 hits in Corpus Corporum as of September 2018; 54 of them were from Aquinas, which reflects his influence). It is first attested in Late Antiquity.

Springhetti then (p. 93) – after acknowledging that *scientia*, *ars,* and *disciplina* are often synonyms in Antiquity (see chap. 3 below) – offers nuances of distinction used in scholasticism and based on Isidore (*Etymologiae* I.1.1–3; quoted in §3 above): *ars* is *legum et praeceptorum, agit de verisimili atque opinabili* ('about laws and precepts, it attends to the probable and to what is open to opinion'), *disciplina* about *de iis quae aliter se habere non possunt* ('what cannot be different'), which in the modern understanding of nature could be taken to mean empirical sciences and a priori sciences respectively. *Scientia* is said to encompass both of these, and *doctrina* is the *institutio, actio docendi* ('the act of teaching').

This brief survey of some early modern reference works has made clear the central importance of proof (*demonstratio*), certainty (*certa cognitio*), and experience (*experientia*) for the early modern understanding of the nature of *scientia* – but not that a topic *natura* was a necessary ingredient. These are criteria that will also prove useful in our own tentative characterisation below (chap. 4). The Latin-writing authors of the Scientific Revolution (see chap. 13) use *scientia* as the normal term for what they are revolutionising.[50]

Excursus on Arabic

§6 As Arabic translations of Greek science will become an important source for Latin science in the twelfth and thirteenth centuries, a brief look at terminology in that language is included here. The Arabic translators consistently use *ʿilm* – a verbal noun (*maṣdar*) derived from the root *ʿlm* meaning 'to know' – to translate ἐπιστήμη. Only in post-Quranic language does this word acquire a plural (*ʿulūm*) signifying '[t]he sciences, or several species of knowledge' (Lane, s.v.), apparently by taking over the semantics of ἐπιστήμη. Arabic can differentiate between the broader and the narrower meanings of ἐπιστήμη, as the former can be rendered as *maʿrifa* ('knowledge'). The history of the Arabs' importing of Greek science and philosophy is excellently covered by Endress, whose work is recommended for more details.[51] Greek learning from late antique Alexandria in particular usually passed into Arabic through Christian Syriac. The difficult translation step was that from Greek to the linguistically unrelated Syriac; from that to the closely related Arabic was much less difficult. The Syriac translators used similar methods to those of the Latin translators half a millennium later. Baumstark (1900: x) had already pointed out:

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50 The encyclopaedias by Cardano (*De subtilitate*, Basileae, 1552), Hofmann (*Lexicon universale,* Lugduni Batavorum, 1698), and Plexiacus (*Lexicon philosophicum,* Hagae Comitis, 1716) did not yield anything of interest to the present discussion.

51 Endress (1982–1992: 2:400–506).

> Die Syrer mussten hundertfach ihrer Sprache Zwang anthun, um dem so oft schon im Griechischen wenig anmutigen schulmäßigen Ausdruck aristotelischen oder aristotelisierenden Denkens gerecht zu werden. In Terminologie und Syntax macht sich überall eine mechanische Nachbildung griechischer Diction geltend.
> 'The Syrians had to do violence to their language a hundred times over in order to do justice to the scholarly expression of Aristotelian or Aristotelising thought, which is often lacking in elegance even in Greek. In terminology and syntax, a mechanical replication of Greek diction asserts itself everywhere.'

A systematic Arabic translation movement culminated under Caliph al-Ma'mūn (r. 813–833). The arduous development of an adequate Arabic language with which to express Greek science has been traced by Endress.[52] The first generation of translators used the *verbum de verbo* technique, just as the twelfth-century Latin translators were to do (see chap. 10 §5 below). This works even less well in Arabic than in Latin, and Ḥunayn ibn 'Isḥāq (809–873; known in Latin as Iohannitius) already translated *sensum de senso*. The translators of his generation established standard translations for Greek technical terms that have usually remain unchanged up to this day (Endress 1982–1992: 3:7, with examples). In some cases (also like in Latin), Greek words seemed untranslatable and were taken over as loanwords: φιλοσοφία > *falsafā*, ὕλη > *hayūlā*, στοιχεῖον > *usṭuquss*. As expected, the first translators resorted to this more often than later ones (16).

The indexes of *Aristoteles Semitico-Latinus* show that *ʿilm* is usually rendered as *scientia* by the Latin translators from Arabic, also including syntagms such as *al-ʿilm al-ṭabāʿiy = scientia naturalis*. Occasionally, *ʿilm* was rendered as *comprehensio* or a nominal *scire*. The indexes for the Latin Albumasar edition by Keiji Yamamoto & Charles Burnett show that *ʿilm* was always rendered as *scientia* in this work. Also there, *disciplina* tends to stand for *adāb* ('discipline') or *taʿallum* ('action of learning'). Freytag (s.v. '*adāb*') defines *adāb* more generally as *omnium rerum scientia, qua a vitiis omnis generis cavere possumus* ('the knowledge of all things by which we can avoid faults of all kinds') and *ʿilm* as *scientia, eruditio*.[53] There are other cases of Arabic technical terms that seem to correspond very well to Greek ones. The word *kalām*, which will be used for 'Islamic theology', fills a surprisingly similar, wide spectrum of meaning as λόγος, including the very similar root meaning *klm* ('to speak'). In the Latin Albumasar, it is usually rendered as *sermo*.

52 Endress (1982–1992: 3:3–23); 'in einem spröden, für wissenschaftliche Differenzierung und Abstraktion noch ungeeigneten sprachlichen Medium' ('in a brittle linguistic medium that was still unsuitable for scientific differentiation and abstraction'; 3).

53 By the way, Modern Arabic still uses *ʿilm* in the wide meaning of *Wissenschaft*, as a glance at the Arabic Wikipedia page (https://ar.wikipedia.org/wiki/علم) shows.

3 The wider semantic field of 'science' in the classical languages

§1 The insight that words are not atom-like entities that bear meaning by and in themselves without relation to others, but that they ought rather to be likened to Leibnizian monads that mirror all other monads in a large network, was first developed by Jost Trier.[1] The German scholars Jost Trier and Walter Porzig address semantic fields as *Sinnbezirke*, *Wortfelder*, or *Bedeutungsfelder* and point out that semantics must take into account the structure of language. Indeed, there is usually semantic anisomorphism between languages, as few (if any) words cover exactly the same semantic ground in any two languages. A prime example of this are colour words, which cover a physically 'objective' radiation spectrum very differently in different languages. Such (admittedly not always so easily definable) 'denotational fields' are divided differently in different languages. There is no need to enter here into the (difficult) theoretical discussions about how exactly such fields should be conceived of and how they can be precisely defined; instead, semantic fields will be employed in this chapter simply to study terms for activities similar to those we call scientific today, and their names in Greek and Latin. The present chapter will thus take a look at the most important related terms in the ancient languages; chapter 5 will then seek to visualise a web of meaning between them.

§2 We have seen that awareness of a concept 'science' was still in a nascent phase in the time of Plato and Aristotle – indeed, it was strongly shaped by the latter – and such a concept was not yet clearly fixed to any single Greek word. Taking a look at the usage of other terms for the scientific acquisition of knowledge at that time will thus be rewarding. In many cases, this vocabulary was later taken over by Latin one-to-one. Latin used a kind of *interpretatio romana* not only for Greek divinities[2] but also for philosophical and scientific terminology. Even in the first century BC or earlier, Classical Antiquity often fixed the translations of these

1 The theory of such semantic fields goes back to Trier (1931). He points out: 'Die Geltung eines Wortes wird erst erkannt, wenn man sie gegen die Geltung der benachbarten und opponierenden Worte abgrenzt. Nur als Teil des Ganzen hat es Sinn: denn nur im Feld gibt es Bedeutung' ('The purport of a word is only recognised when it is distinguished from the purport of neighbouring and opposing words. Only as part of the whole does it make sense: for only in the field does meaning exist'; 6). Today, such approaches have led to very promising digital approaches such as WordNet (https://wordnet.princeton.edu), which are, however, still very much in their infancy.
2 This sometimes led to questionable results, such as Diana = Artemis.

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Greek words to exactly one Latin equivalent in each case.[3] The corresponding Greek and Latin words will therefore be studied together in this chapter. Several circles of key terms around the concept 'science' may be distinguished. The broader ones are only hinted at; this chapter focuses on near-synonyms of ἐπιστήμη/*scientia*. Antonymic terms will not be considered, except in passing if they help determine the exact meaning of the positive terms. The approach here will try to remain descriptive and, as far as possible, to understand the web of meaning among the words in question independently of their diachronic development; the latter is of course undeniable and will be treated in part 2 of the book. The focus here will be on the meanings these key terms acquire in classical times: for Greek its classical age around the fourth century BC, and for Latin the two centuries around the birth of Christ. Some remarks on later use, especially at the late mediaeval universities, are interspersed.[4]

The history of philosophical and scientific Latin (and Greek) terminology has been studied occasionally since the Renaissance, especially by some of the reference-work authors encountered above: Rudolph Goclenius' *Lexicon philosophicum* (1613), Étienne Chauvin's *Lexicon rationale* (1692), or Plexiacus' *Lexicon philosophicum* (1716).[5] Beyond the linguistic medium of Latin, Eucken's fundamental, although in its conclusions sometimes rather sweeping, *Geschichte der philosophischen Terminologie* (1879) and Snell's (1924) dissertation on the Greek terminology of knowledge provide information for the present chapter.

We begin by returning to the verbs that denote knowledge in the classical tongues. There are, in the main, three in each language: ἐπίσταμαι, οἶδα, γιγνώσκω;[6] *scio*, *sapio*, *(cog)nosco* – they tend to correspond to one another in that order. The words had in classical times largely become synonyms, although in some authors (such as Aristotle, as pointed out above) ἐπίσταμαι tends to denote more certain, 'scientific' kinds of knowing. The character of the perfective οἶδα is a comprehensive 'having seen and grasped something'. The missing present and aorist forms for it are usually supplied from γιγνώσκω. The aorist that corresponds to this perfective form (ἰδεῖν) still means 'to see', and Plato's 'idea' (both ἰδέα and εἶδος) is derived from this same root. The Latin verb *scio* may be related to *scindo* ('cleave')

3 The later use of some of these words among Latin translators can be seen in Roelli (2014a: 950–953) and in more detail online at http://mlat.uzh.ch/MLS/texts/technica.html.

4 This setting sees important change and is well documented by Teeuwen's (2003) encyclopaedic work.

5 On some of these lexicons, see Canone (1997).

6 γνωρίζω could be added as a verb for 'become acquainted with', but it is often hardly distinguishable from mere 'to know'. *Metaphysica* A1, 981a, where Aristotle uses it as a synonym for οἶδα, is quoted below.

and thus etymologically mean something like 'to distinguish',[7] while *sapio* primarily meant 'to taste'. *Cognosco* stems from the same Indo-European root for 'to know' (**ǵenh₃*) as γιγνώσκω, with a preverb *con-*. For all these verbs it is possible to form nominal abstract terms: ἐπιστήμη, εἴδησις and ἱστορία, γνῶσις; similarly in Latin: *scientia*, *sapientia*, *cognitio* and (rare) *gnaritas*.[8] The nuances, however, differ to some extent: *sapientia* usually translates σοφία (which lacks a corresponding primary verb in Greek), while γνῶσις has a tendency toward mystical knowledge, which *cognitio* lacks. This latter word stays close to the general meaning of *scientia*, mainly adding to it an inchoative character, thus tending toward 'getting to know, realising, becoming acquainted, cognisance'.

It has been shown that a concept of 'science' is only emerging in Greek Antiquity, but even for Hellenistic times D'Ooge can still claim (1926: 16) that τέχνη, πραγματεία,[9] μέθοδος, and ἐπιστήμη 'were used in about the same sense, as "a system or body of rules and principles" of any art'. Among the Latin terms – especially *scientia, ars, disciplina, doctrina* – a similar situation can be observed (e.g. Teeuwen 2003: 358–360). At a closer look, however, differences do appear, although the usage can vary between authors, schools, and periods; for instance, τέχνη is used by the Hippocratic authors in the way Aristotle would use ἐπιστήμη. Some such near-synonyms will be discussed in more detail in what follows. The closest semantic field consists of terms that can denote scientific activity or the acquisition of scientific knowledge, besides the pair ἐπιστήμη–*scientia*, which was considered above.

μάθημα, μάθησις – *disciplina*

§3 The rather broad Latin term *disciplina*[10] ('branch of learning; instruction; (military) discipline') often corresponds to what we would call 'science' in Latin Antiquity. Etymologically, it corresponds best to μάθημα (often plural), as it was felt to belong to *disco* (cf. the Isidore quotation at the end of this section). Μάθημα is an-

7 See de Vaan (s.v. *scio*), and *LIV* under √**sekH*: 'abtrennen: 1. schneiden, 2. unterscheiden' ('sever: (i) cut, (ii) discern').
8 Among antique authors *gnaritas* is used only a few times, by Sallust and Ammianus Marcellinus, apparently always in conjunction with *locorum*.
9 This word is sometimes used to denote a philosophical system or a 'systematic or scientific historical treatise', but more often the word means in general any 'prosecution of business, diligent study' (LSJ, s.v.), and it is not considered further here.
10 Probably from**dis-capio* ('take up mentally'), leading to *discipulus*, thence *disciplina*, with probable semantic influence from *disco* (see Walde & Hofmann, s.v. *disco*).

other word apparently not found in Ionic but frequent in Attic,[11] whereas the more active, subjective form of acquiring 'learning' is called μάθησις, also in Ionic authors. As the object of learning, μάθημα can correspond to Latin *disciplina* or *doctrina* (on which see §8). However, in Latin *disciplina* often designates the various fields of *scientiae* and *artes,* while μάθημα develops from 'learning' in general more and more toward mathematical learning. The Pythagorean Archytas (d. ca. 350 BC) already used it to denote something like 'exact, mathematical science' (D14 LM = B1 DK):

> καλῶς μοι δοκοῦντι τοὶ περὶ τὰ μαθήματα διαγνῶναι καὶ οὐθὲν ἄτοπον ὀρθῶς αὐτοὺς οἷά ἐντι, περὶ ἑκάστου θεωρεῖν. περὶ γὰρ τᾶς τῶν ὅλων φύσιος καλῶς διαγνόντες ἔμελλον καὶ περὶ τῶν κατὰ μέρος, οἷά ἐντι, ὄψεσθαι. περί τε δὴ τᾶς τῶν ἄστρων ταχυτᾶτος καὶ ἐπιτολᾶν καὶ δυσίων παρέδωκαν ἁμῖν διάγνωσιν καὶ περὶ γαμετρίας καὶ ἀριθμῶν καὶ οὐχ ἥκιστα περὶ μωσικᾶς. ταῦτα γὰρ τὰ μαθήματα δοκοῦντι ἦμεν ἀδελφεά.
> 'It seems to me that those studying the μαθήματα discern well, and it is by no means strange that they are able to think correctly about each thing. For as they discerned the nature of everything well, they will also understand how its parts are. They handed down to us clear insight about the speed of the heavenly bodies and their rising and setting, equally about geometry, numbers, and not least about music. For these μαθήματα seem to be siblings of one another.'

So the mathematical sciences that will become the *quadrivium* (geometry, arithmetic, astronomy, music) are here already seen in close kinship and called τὰ μαθήματα. In Aristotle μαθήματα is exclusively used for mathematical learning, alongside μαθηματική (*sc.* ἐπιστήμη, as in Hero [?], *Definitiones* 138.4, ed. Heiberg, p. 162). This 'mathematics' usually also contains the other mathematical disciplines such as optics, acoustics, statics, and astronomy (and with it astrology). Aulus Gellius writes that (*Noctes atticae* I.9.6, ed. Marache, vol. 1, p. 39)

> *geometriam, gnomonicam, musicam ceterasque item disciplinas altiores μαθήματα veteres Graeci appellabant.*
> 'the older Greeks called geometry, the art of making sundials, music, and the other similar higher disciplines μαθήματα'.

The Greek word is also used in Latin (incidentally hinting that *disciplina* was not felt to be close enough to convey the meaning of μαθήματα) for 'mathematics'. An exception is found again in Aulus Gellius (XIV.3.5–6, vol. 3, p. 134), who indeed translated μαθήματα with mere *disciplinae*.

11 Like ἐπιστήμη (see above). See Snell (1924: 86, and 72–81 on μάθημα).

From Roman times onward, *mathematica* can as *totum pro parte* also denote 'astrology', for example in Suetonius.[12] In legal terminology, this meaning can still be found in the *Codex Iustinianus* in a decree of the year 294:[13]

> *Artem geometriae discere atque exerceri publice intersit. Ars autem mathematica damnabilis interdicta est.*
> 'To teach or to practise the art of geometria is to be of public interest. The damnable "mathematical" art, however, is forbidden.'

Later, a poem by Bernardus Silvestris (fl. 1147) asserting freedom from astrological fatalism is called *Mathematicus*.[14] Hugh of St Victor even uses *mathematica* in the sense of 'magic arts' in general (besides using the same word for the *quadrivium* in its entirety):[15]

> *Mathematica dividitur in tres species: in aruspicinam, in augurium, in horoscopicam.*
> '*Mathematica* is divided into three species: inspection of victims, augury, horoscope casting.'

The more usual, narrow, use of the term as we find it today in English is defined by Johann Christoph Heilbronner (1706–1747) in his *Historia matheseos* (p. 1) thus:[16]

> *Mathesis est scientia, omnia, quae numero gaudentur, dimetiendi.*
> '*Mathesis* is the science of measuring everything that admits of number.'

In this narrow sense of 'mathematics', we see that the Greek term has not found a translation in Latin or the modern vernaculars but is used *tel quel,* both as *mathematica* and *mathesis*. Most modern European vernaculars use the Greek word when they speak of 'mathematics'. Exceptions are Dutch *wiskunde* (literally 'study of knowing') and Icelandic *stærðfræði* (literally 'study of quantity'), which use typically Germanic compounds.

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12 Tiberius 69, Nero 40, ed. Ailloud, vol. 2, pp. 54, 187.
13 C 9.18.2, ed. Krüger & Mommsen: *De maleficiis et mathematicis et ceteris similibus* ('On sorcery and "mathematics" and other similar arts'). The background is that the emperors were understandably particularly unhappy with astrologers predicting their death date.
14 It is based on a Pseudo-Quintilian declamation from which Bernardus will have taken this usage. Much later, Gian Vittorio Rossi, *Eudemia* VIII.20, ed. Nelson, p. 398, still uses *mathematicus* in this sense.
15 *Didascalicon* 6, appendix C, ed. Offergeld, pp. 410–412. The authenticity of this appendix is unclear (p. 403).
16 Heilbronner *Historia matheseos*, p. 13, also points out the various uses mentioned above.

As has already been mentioned, the word *disciplina* has a broad spectrum of meaning; it can also translate παιδεία[17] or be synonymous with *eruditio*.[18] The loanword 'discipline' is still used today in rather different meanings: from παιδεία to 'branch of a science'. In Antiquity *disciplina* often means '(one specific branch of) science', and indeed not only or not even usually only the mathematical sciences.[19] In fact, the word can translate ἐπιστήμη, especially in Platonic contexts.[20] Calcidius[21] translates ἐπιστήμη once as *scientia* and once as *disciplina* in his translation of the *Timaeus;* on the other hand, he also once translates μάθημα as *scientia*. As Lewis & Short (s.v.) put it, *disciplina* can be 'all that is taught in the way of instruction, whether with reference to single circumstances of life, or to science, art, morals, politics, etc.'. Teachability and a systematic nature are thus central for *disciplina;* so, Cicero's contemporary Aulus Caecina Severus spoke in his (lost) work on divination of the *etrusca disciplina*. His aim will have been to reconcile Etruscan lore with the Stoic 'scientific' worldview that was current at the time.[22] Vitruvius (I.1.12) speaks of the unity of all *disciplinae* (quoted in chap. 4 §5 below).

In Latin Antiquity, *philosophia* itself is also a *disciplina*, indeed the 'royal' one (*disciplina regalis*) for Apuleius (*Florida* 7, ed. Vallette, p. 134); or, conversely, all branches of science and learning can be *disciplinae* of *philosophia*.[23] Indeed, Apuleius seems to use *ars*, *disciplina*, and *doctrina* as synonyms (Bovey 2003: 73), as does Augustine (with the addition of *scientia*; 76). Bovey comes to the conclusion that these Latin words started out more or less synonymous and it was only in Late Antiquity that some writers tried to distinguish nuances in them. Given their mostly obvious link to existing Greek terminology, this looks like an oversimplification, at least where authors aware of these Greek nuances are concerned. Nonetheless, it seems that in Latin Antiquity *scientia* and *disciplina* can both be used to

17 e.g. Augustine, *Enarrationes in Psalmos* Ps 118, sermo 17.2, ed. Dekkers & Fraipont, vol. 3, p. 1719: *[...] disciplinam quam Graeci appellant παιδείαν* ('[...] *disciplina*, which the Greeks call παιδεία').

18 e.g. Rufinus, *Basilii homilia* 5.5, ed. Lo Cicero, p. 88: *Disciplina vel eruditio est institutio quaedam cum labore adhibita animae* ('*Disciplina*, or *eruditio*, is a certain institution applying labour to the soul').

19 On this term's broad spectrum of meanings, see Mauch (1941) and also Hadot (1984: 90 and *passim*).

20 e.g. Apuleius, *De Platone et eius dogmate* II.9, ed. Beaujeu, p. 86, or Ps-Augustine, *Categoriae* 11.95, ed. in *Aristoteles Latinus* 1.1–5, p. 154.

21 According to the word index of Waszink's edition, where loci can be found.

22 Some fragments are preserved by Seneca in his *Naturales quaestiones* II.31–49, ed. Hine, pp. 88–97 (on lightning).

23 e.g. Cicero, *Lucullus* 3.7, ed. Plasberg, p. 29.

denote 'science', often being more or less synonymous, with the difference that *scientia* also has the wider meaning of 'knowledge' (as seen in chap. 2 §5 above) and *disciplina* a connotation of various branches of learning. Isidore (*Etymologiae* I.1.1–3, ed. Lindsay) puts it thus:[24]

> *De disciplina et arte. Disciplina a discendo nomen accepit: unde et scientia dici potest. Nam scire dictum a discere, quia nemo nostrum scit, nisi qui discit. Aliter dicta disciplina, quia discitur plena. Ars vero dicta est, quod artis praeceptis regulisque consistat. Alii dicunt a Graecis hoc tractum esse vocabulum ἀπὸ τῆς ἀρετῆς, id est a virtute, quam scientiam vocaverunt. Inter artem et disciplinam Plato et Aristoteles hanc differentiam esse voluerunt, dicentes artem esse in his quae se et aliter habere possunt; disciplina vero est, quae de his agit quae aliter evenire non possunt. Nam quando veris disputationibus aliquid disseritur, disciplina erit: quando aliquid verisimile atque opinabile tractatur, nomen artis habebit.*
> 'On *disciplina* and *ars*. *Disciplina* comes from *disco* [to learn], whence it can also be called certain knowledge [*scientia*], as "to know" [*scio*] comes from "to learn" [*disco*], because none of us knows unless he learns [*disco*]. In another manner, *disciplina* is said because it is learned [*disco*] fully [*plenus*]. In fact, *ars* is called so because it consists of strict [*artus*] precepts and rules. Others say that it is derived from the Greek word ἀρετή, that is, from the "virtue" called certain knowledge [*scientia*]. Between *ars* and *disciplina* Plato and Aristotle would posit the distinction that *ars* is about things that can also be different, but *disciplina* is about things that cannot turn out differently. So, when something is studied using true arguments it will be a *disciplina*, when it is treated in a manner [only] resembling truth and open to opinion, it will have the name *ars*.'

Thus, Isidore (or his source) is clearly taking *disciplina* to be the Roman translation of ἐπιστήμη in this quotation and *scientia* as a synonym for it. This approach is common; the medical writer Ps-Soranus (Late Antiquity), for instance, writes similarly (*Quaestiones medicinales,* ed. Fischer, p. 33):

> *Quid est disciplina? disciplina est scientia immutabilis cum ratione.*
> 'What is *disciplina? Disciplina* is immutable knowledge based on reason.'

As mentioned above, only in the twelfth century is *scientia* finally preferred (over *disciplina*) as the standard Latin term for 'science'. This will be pursued below (chap. 10 §6).

τέχνη – *ars*

§4 The pair of terms τέχνη and *ars* correspond much more closely to one another than μάθημα and *disciplina*. According to *TLL* (s.v.), *ars* was a

24 See the discussion of this passage in Hadot (1984: 207–208).

> *vox rara apud priscos, dein per totam viguit latinitatem. notionem primitivam in prosam induxere Sall. Liv. Tac. potissimum.*
> ‘rare word among the old writers; thereafter it becomes common throughout all of Latinity. Its basic notion was mostly introduced to prose writing by Sallust, Livy, Tacitus.’

Among the old writers who do use the word quite often is Plautus, where it tends to mean a ‘gute od. schlechte Eigenschaft, Gewohnheit, Handlungsweise, Tugend od. Untugend, Laster’ (‘good or bad quality, habit, conduct, virtue or lack thereof, vice’; Georges, s.v. *ars*),[25] a usage that led later authors to an *etymologia* from ἀρετή = *virtus*.[26] From the Auctor ad Herennium and Cicero onward, the word is usually very similar in meaning to τέχνη. Our ‘art’ is, of course, derived from *ars*, but both the Greek and the Latin words had no connotation of virtuosity, unlike the English ‘art’ or German *Kunst*.[27] Generally, τέχνη/*ars* is understood as a more practical, and ἐπιστήμη/*scientia* as a more theoretical ‘science’, but this was not the case from the beginning. The word τέχνη[28] is related to τέκτων (‘carpenter; craftsman’) in general, but also τίκτω (‘bring into the world, engender’, esp. children) and to Sanskrit *√takṣ* (‘fashion, form, invent’);[29] these words have a definite practical connotation in common. The basic meaning of τέχνη is ‘art, skill, cunning of hand’.[30] Nonetheless, the Hippocratic writers use τέχνη for their medical ‘art’, although they certainly mean to emphasise its factual and often theoretical, thus scientific character. Snell (1924: 85) relates this to their Ionic dialect, which may have lacked the word ἐπιστήμη.[31] They often contrast it to τύχη (‘randomness’), with which it alliterates conveniently. The understanding of τέχνη in the Hippocratic treatise *De arte* is apparent in the very first sentence (1.1, ed. Jouanna et al., p. 224):

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25 But the later meaning close to *disciplina* can already be found too; e.g. *Miles gloriosus* 2.2, line 32, ed. Lindsay, vol. 2. The *ars parasitica* in *Captivi* 3.1, line 9, vol. 1, illustrates the transition between the two meanings well; see Lodge (s.v. *ars*).

26 e.g. Isidore, just quoted.

27 This difference is explored by Heidegger’s (1977) study of the *Kunstwerk*.

28 Löbl (1977–2008) has collected many passages containing the term τέχνη, from Homer to Aristotle.

29 Thus Mayrhofer (1956–1980: 1:468). The χ is regular: τέχνη < **teks-nā*.

30 Heidegger (1979: 203) translates as ‘Sichauskennen in etwas’.

31 Snell (1924) found only one occurrence of the word ἐπιστήμη in Ionic: Democritus D385 LM = B181 DK, where it seems to be used as a near-synonym of σύνεσις (‘sagacity, intelligence, knowledge, insight’), another word that is occasionally used to denote branches of science, once in Aristotle, *Politica* IX.8, 1342b8, speaking about the ‘science’ of music.

> Εἰσίν τινες οἳ τέχνην πεποίηνται τὸ τὰς τέχνας αἰσχροεπεῖν, ὡς μὲν οἴονται οὐ τοῦτο διαπρησσόμενοι ὃ ἐγὼ λέγω,[32] ἀλλ’ ἱστορίης οἰκείης ἐπίδειξιν ποιεύμενοι.
> ‘There are some who have made it an art to vilify the arts, but they do not intend to accomplish what I say, they do it in order to demonstrate their own erudition [ἱστορίη].’

Thus, it seems that for this author a τέχνη is characterised by determined, goal-directed, methodical action, the aim in this case being to vilify the arts, especially medicine. Similarly, Plato (*Theaetetus* 198a) seems to understand ἐπιστήμη as ‘knowledge, understanding’ in general, but τέχνη as a rule-based ‘scientific discipline’:

> ΣΩ. ἀριθμητικὴν μὲν γὰρ λέγεις τέχνην;
> ΘΕΑΙ. Ναί.
> ΣΩ. Ταύτην δὴ ὑπόλαβε θήραν ἐπιστημῶν ἀρτίου τε καὶ περιττοῦ παντός.
> ‘SOCRATES: Do you call arithmetic an art?
> THEAETETUS: Yes.
> SOCRATES: Understand it fully as chasing after (scientific) knowledge of even and odd [numbers].’

In *Gorgias* (465a) Plato distinguishes τέχνη (‘art, craft’) from ἐμπειρία (‘practice, craft without understanding’; as Plato says, οὐκ ἔχει λόγον οὐδένα, ‘it has no rational understanding’) – a distinction that often recurs in later writers. Already in Plato, τέχνη can also denote a technical treatise (e.g. *Phaedrus* 271c). For Aristotle, τέχνη and ἐπιστήμη are often synonymous (e.g. *Metaphysica* A1, 981a2),[33] but in some passages he stresses that the former is more practical, as in *Metaphysica* Λ9, 1075a1–3, where the τέχναι are defined as ποιητικαί. Aristotle provides a more detailed differentiation of ἐπιστήμη and τέχνη in *Ethica Nicomachea* (VI.3–4, 1139b15–1140a23):

> ἔστω δὴ οἷς ἀληθεύει ἡ ψυχὴ τῷ καταφάναι ἢ ἀποφάναι, πέντε τὸν ἀριθμόν· ταῦτα δ’ ἐστὶ τέχνη, ἐπιστήμη, φρόνησις, σοφία, νοῦς· ὑπολήψει γὰρ καὶ δόξῃ ἐνδέχεται διαψεύδεσθαι. [...] ἐξ ἀνάγκης ἄρα ἐστὶ τὸ ἐπιστητόν. ἀίδιον ἄρα· τὰ γὰρ ἐξ ἀνάγκης ὄντα ἁπλῶς πάντα ἀίδια, τὰ δ’ ἀίδια ἀγένητα καὶ ἄφθαρτα. ἔτι διδακτὴ ἅπασα ἐπιστήμη δοκεῖ εἶναι, καὶ τὸ ἐπιστητὸν μαθητόν. ἐκ προγινωσκομένων δὲ πᾶσα διδασκαλία, [...]. ἡ μὲν οὖν τέχνη, ὥσπερ εἴρηται, ἕξις τις μετὰ λόγου ἀληθοῦς ποιητική ἐστιν, ἡ δ’ ἀτεχνία τοὐναντίον μετὰ λόγου ψευδοῦς ποιητικὴ ἕξις, περὶ τὸ ἐνδεχόμενον ἄλλως ἔχειν.

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32 Emendation by Gomperz; most manuscripts have οἱ τοῦτο διαπρησσόμενοι, οὐχ ὃ ἐγὼ λέγω.
33 καὶ δοκεῖ σχεδὸν ἐπιστήμῃ καὶ τέχνῃ ὅμοιον εἶναι καὶ ἐμπειρία, ἀποβαίνει δ’ ἐπιστήμη καὶ τέχνη διὰ τῆς ἐμπειρίας τοῖς ἀνθρώποις (‘And it seems that experience is nearly the same as science or art, but science and art reach man through experience’).

'There will be five means by which the soul can possess truth by affirming or denying; they are practical art, scientific knowledge, practical wisdom, philosophical wisdom, intuitive intellect; for suspicion and opinion can also be wrong. [...] Therefore, the scientifically knowable is of necessity. Thus also eternal; for all things that are of necessity in an unqualified way are eternal. Eternal things are uncreated and imperishable. Again, every science is thought to be teachable, and the scientifically knowable learnable. All teaching comes from what is previously known, [...] art, therefore, as has been said, is a productive state with true reasoning, lack of art contrariwise is a productive state with false reasoning about matters that can also be different.'

Several characteristics of science (ἐπιστήμη) are named here that we would still agree with today: it is teachable, it seeks certainty, and it takes what is already known as its point of departure. On the other hand, the objects of τέχνη are things to be made or constructed; τέχνη is the means to rationally make or produce them, so approaching our 'technology'. Thus, with Aristotle the distinction between *scientia* and *ars* that was to become standard in Greek and in Latin is reached. For him, something may happen naturally, by chance, or by art.[34] The artist (*artifex*) usually strives to produce a work (ἔργον, *opus*), again like our 'technology' and unlike our 'science'. This connotation continues into early modern times: a healthy patient in the *ars medica,* the 'stone' in the *ars alchemica,* or a 'work' may be a piece of art – it would seem that our modern concept of art is derived from this emphasis on the 'work'. This connotation is absent from *scientia*, whose aim is pure knowledge for its own sake. But *ars* is not the blind fashioning of a work; it proceeds with λόγος (Aristotle, *De partibus animalium* I.1.16, 640a31–32):

Ἡ δὲ τέχνη λόγος τοῦ ἔργου ὁ ἄνευ τῆς ὕλης ἐστίν.
'But art is a conception [λόγος] of the work before it is put into matter.'

In the wake of Aristotle, Lausberg (1990: 26) can present the following definition:

34 Lausberg: 'Ein geordneter, auf Vollkommenheit zielender Vorgang kann von Natur aus (φύσει = naturā) vor sich gehen, also dem natürlichen Geschehensablauf entsprechen (z. B. das Wachsen eines Baumes). Entspricht er nicht dem natürlichen Geschehensablauf, so kann er durch Zufall (τύχῃ = casu) oder durch eine von einem vernünftigen Wesen (Mensch) planvoll ins Werk gesetzte Handlung (τέχνῃ = arte) zustandekommen' ('An orderly process aiming at perfection can happen by nature (φύσει = *naturā*); thus, it can correspond to the natural course of events (e.g. the growing of a tree). If it does not correspond to the natural course of events, it can come about by chance (τύχῃ = *casu*) or by an action planned by a reasonable being (man) (τέχνῃ = *arte*)'; 1990: 25).

> Demnach ist eine *ars* (τέχνη) ein System aus der Erfahrung (ἐμπειρία) gewonnener, aber nachträglich logisch durchdachter, lehrhafter Regeln zur richtigen Durchführung einer auf Vollkommenheit zielenden, beliebig wiederholbaren Handlung, die nicht zum naturnotwendigen Geschehensablauf gehört und nicht dem Zufall überlassen werden soll.
> ‘Thus, an *ars* (τέχνη) is a system of instructive rules, derived from experience (ἐμπειρία) but subsequently logically elaborated for the correct execution of an action aiming at perfection and repeatable at will, one that does not belong to the natural course of events and that should not be left to chance.’

Later on, however, and possibly as a consequence of Aristotle’s usage, the word τέχνη/*ars* often also implies a craft of a practical, economically interesting kind, as can for instance be seen in the later Roman Empire in Philostratus (after AD 217), where the philosopher and sage Apollonius of Tyana, while arguing before Domitian’s court in his defence against the charge of wizardry, stresses that his art does not earn him money (*Vita Apollonii* VIII.7, ed. Mumprecht, pp. 862–864):

> τέχναι ὁπόσαι κατ’ ἀνθρώπους εἰσί, πράττουσι μὲν ἄλλο ἄλλη, πᾶσαι δ’ ὑπὲρ χρημάτων, αἱ μὲν σμικρῶν, αἱ δ’ αὖ μεγάλων, αἱ δ’ ἀφ’ ὧν θρέψονται, καὶ οὐχ αἱ βάναυσοι μόνον, ἀλλὰ καὶ τῶν ἄλλων τεχνῶν σοφαί τε ὁμοίως καὶ ὑπόσοφοι πλὴν ἀληθοῦς φιλοσοφίας.
> ‘All the arts that can be found among men somehow or other producing something do it for money – some for little, some for much, some offer a livelihood, not only the manual ones but also the erudite and nearly erudite ones [ὑπόσοφος] of the other arts – except true philosophy.’[35]

In order to de-emphasise this mercantile aspect, the term ‘*Liberal* Arts’ (ἐλευθέριοι τέχναι, *artes liberales*) came into use.[36] Such Liberal Arts are often opposed to *artes mechanicae* (for practical, mechanical crafts involving the earning of money). The difference between *scientia* and *ars* seems to get further weakened in Late Antiquity.[37] In the Middle Ages these liberal, disinterested, arts become nearly synonymous with *scientia/disciplina,* especially for the mathematical *artes*

35 The sentence is complicated; the word ὑπόσοφος is a *hapax*. The distinction is between handicrafts on the one hand and the Liberal Arts on the other. Of the latter the text mentions later poetry, music, astronomy, the arts of sophists and rhetors, whereas the ὑπόσοφοι τέχναι include practical but not ‘vile’ occupations, such as painting, sculpture, navigation, agriculture.
36 See Hadot (1984); chap. 8 below.
37 See Meißner: ‘Die Unterscheidung zwischen technischen (Mechanik, Medizin) und theoretischen Wissenschaften, die die Wissenschaftgeschichte der klassischen und hellenistischen Zeit prägte, relativiert sich in der Spätantike’ (‘The distinction between technical (mechanics, medicine) and theoretical sciences, which characterised the history of science in the classical and Hellenistic periods, is relativised in Late Antiquity’; 1999: 340). But we have seen that this difference was not so clear-cut in classical times either, especially in Aristotle.

liberales (*quadrivium*), which have never been concerned with an *opus*. In general, the relationship between *ars* and *scientia* continues to vary between authors, but on the whole *ars* remains the more practical and thus less esteemed endeavour, one that may lead the way for practical concerns,[38] while *scientia* remains more based on θεωρία/*contemplatio,* disinterested study.

Some later attempts at definition will now be examined. The late antique grammarian Audax writes with the grammatical art in mind (*Excerpta de Scauro et Palladio*, ed. Keil, vol. 7, p. 320):

> *Ars quid est? Rei cuiusque scientia ad utilitatem delectationemque tendentis usu uel ratione comprehensa.*
> 'What is art? The acquisition of certain knowledge about something which has aims of usefulness and enjoyment, a practical and a rational aspect being included.'

A probably somewhat later grammar, the *Victorini sive Palaemonis ars* (ed. Keil, vol. 6, p. 187), understands *ars* in a wider context: for this author, *ars* involves activities purely of the mind (roughly 'sciences'), purely of the body ('gymnastics'), or of both ('applied sciences'):

> *Ars quid est? Vnius cuiusque rei scientia.*[39] *Artium genera quot sunt? Tria. Quae? Sunt quaedam animi tantum, quaedam corporis, quaedam animi et corporis. Quae sunt animi tantum? Hae sunt, poetice, musice, astrologice, grammatice, rhetorice, iuris scientia, philosophia. Quae sunt corporis? Iaculatio, saltus, uelocitas, oneris gestamen. Quae sunt animi et corporis? Ruris cultus, palaestra, medicina, μηχανική, τεκτονική.*
> 'What is art? The acquisition of knowledge [*scientia*] about anything. How many kinds [*genera*] of arts are there? Three. Which ones? Some are of the mind only, some of the body, some of the mind and the body. Which ones are only of the mind? Those are the sciences of poetics, music, astrology/astronomy, grammar, rhetoric, law, and philosophy.[40] Which ones are of the body? Throwing, jumping, swiftness, carrying of burdens. Which ones are of mind and body? Agriculture, wrestling, medicine, mechanics, carpentry.'

Our conclusions about the relationship between *scientia* and *ars* are explicitly voiced in a later mediaeval author, a Ps-Bede whose *floruit* is unclear, commenting on the *Ethica Nicomachea* passage quoted above. Unfortunately, many of the spurious works of Bede have hardly been studied, and it is often impossible even

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38 See Meißner, who speaks of 'handlungsleitendes Wissen' ('action-guiding knowledge'; 1999: 11).

39 For this definition, cf. Cassiodorus, *Institutiones* II, praef. 4, ed. Mynors, p. 91.

40 Their number is seven, as in the later usual group of Liberal Arts, but they differ greatly; see chap. 8 below. It is interesting to note that these 'sciences' and philosophy are all *artes* for this author.

to tell what century they belong to. The text shows Aristotelian usage of *scientia* in many definitions (PL 90.968C):[41]

> *Ars et scientia distinguuntur (VI Ethic.): Debet intelligi capiendo scientiam stricte solum pro habitu speculativo, et etiam capiendo artem stricte solum pro habitu practico. Sed capiendo aeque communiter tam pro habitu practico quam speculativo, tunc non distinguuntur.*
> 'Art and science are distinguished (*Ethica Nicomachea* VI): strictly speaking, science must only be understood if there is a theoretical character, and similarly art strictly only in case there is a practical one. But seizing upon equally the practical and the speculative character, they are not distinguished.'

This distinction between ἐπιστήμη and τέχνη is already translated more loosely, but tellingly, by Vitruvius,[42] where the former corresponds to *ratiocinatio* and the latter to *opus,* in other words again respectively to theoretical understanding and to practical science producing a 'work'. There are also other nuances of difference: thus, according to Menuet-Guilbaud (1994: 84) for Cicero *ars* – among other meanings – means a 'science particulière' ('particular science'), whereas *disciplina* means the 'contenu d'un enseignement, matière enseignée' ('the content of teaching, taught subject-matter'). The latter is the more specialised term for Cicero (88).

What is common to all of these ways of understanding τέχνη/*ars* is the practical character of producing a work, except for the Liberal Arts. The terms can be seen as another ancestor of our 'science': in the Middle Ages, *artes* (*liberales*) are often close to our 'science', but in the Scientific Revolution (see chap. 13 below) of early modern times, which emphasises the importance of empiricism and experimenting – things that would traditionally be at best marginal for *scientia* but pertain to the more intellectual *artes* – the differences are further blurred. Only in post-Latin times have the terms 'science' and 'art' parted ways quite neatly.

In part 2 of this book, it will become clear that in Roman and early mediaeval times 'science' was largely seen as part of the general, higher education of free men, not specialist work, so the sciences are often called *artes liberales,* but also *litterae* or more clearly *disciplinae litterarum.* These 'letters' already contained more than literature for Cicero, who uses combinations such as *litterarum scientia*, *litterarum cognitio*, or *nescire litteras* (meaning 'to be without a liberal educa-

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41 No information about this certainly late florilegium (twelfth or thirteenth century?) can be found in Jones (1939) or in the online ALCUIN portal at the University of Regensburg (https://www-app.uni-regensburg.de/Fakultaeten/PKGG/Philosophie/Gesch_Phil/alcuin/work.php?id=20655). The Aristotelian passage intended may be *Ethica Nicomachea* X.10, 1180b13–23.
42 *De architectura* I.1.15, ed. Fensterbusch, p. 32.

tion' and contrasting with *scire litteras*).[43] Cicero's terms *studium litterarum* and *scientia litterarum* remain common throughout the Middle Ages.

ἱστορία – *historia*

§5 This is a typically Ionian term (in the form ἱστορίη) and thus contrasts with the Attic ἐπιστήμη. As mentioned above, it derives from the root of οἶδα (ϝιδ), which is the same root present in German *wissen* ('to know') and Latin *video* ('to see'). A *nomen agentis* ἵστωρ exists already in Homer in the juridical context of '(eye-)witness'. From this a verb ἱστορέω, first and profusely attested in Herodotus, is formed, originally as 'to be an eye-witness';[44] ἱστορία is thus the researching of an event through eye-witnesses. The word was also used in some contexts by Aristotle (some twenty-eight times), especially for mostly descriptive scientific activities, for which he often uses ἱστορία,[45] most prominently in the title of his *Historia animalium*. The *interpretatio romana* will find no suitable Roman word to translate this Ionian concept (just as English has not), and merely transliterates it as *historia*.[46] There was a similarly formed word in Latin, *speculatio*, also from a verb meaning 'to spot' or 'to see' like οἶδα, but this word had already become the usual Latin term for θεωρία. Apparently, the word ἱστορίη could in early times stand for 'science' in general. We read in Iamblichus (*De vita Pythagorica* 18.89, ed. Klein, p. 52):

> ἐκαλεῖτο δὲ ἡ γεωμετρία πρὸς Πυθαγόρου ἱστορία.
> 'Geometry was called ἱστορίη by Pythagoras.'

But usually, ἱστορία/*historia* has – in contrast to the other words for 'science' – a tendency to imply a kind of knowledge of 'historical' facts, that is, an emphasis on their temporal development and, often, their uniqueness: it tends to describe them more than to explain them from first principles.[47] Both these points separate

43 Respectively: *Brutus* 42(153), ed. Martha, p. 53; *De oratore* III.32(127), ed. Kumaniecki, p. 310; *Brutus* 74(259), ed. Martha, p. 93; *De finibus* II.4(12), ed. Moreschini, p. 38.

44 See Snell (1924: 63). Von Fritz translates ἱστορία with 'Augenscheinnahme' ('visual inspection'; 1952: 202).

45 See further Floyd (1990).

46 In contrast, German has its own term *Geschichte*, an abstract to *geschehen* meaning literally 'what has been happening'. Clearly, the term approaches 'history' from a rather different angle, that of *res gestae*. See Grimm (s.v. 'Geschichte', 3b). The irregular feminine gender (nouns with the collectivising prefix *Ge-* in German are otherwise neuter) is occasionally already attested in Luther; it may well be influenced by the gender of Latin *historia*.

47 Schütze (2000: 25–26) differentiates four meanings of *historia* – in rough paraphrase: mere description (as opposed to demonstration), a *notitia particularis* (as opposed to a *theoria generalis*), such knowledge from ἐπιστήμη, which is of general things that always (or 'for the most part', as Aristotle cautiously tends to add) hold true.[48]

In general, however, both *historia* and *scientia* can be seen as typical, roughly contemporary discoveries of the Greeks, both meaning to get as much and as certain knowledge about something as possible.[49] If the difference between them is only that *historia* does not use first principles and can apply to specific cases, a wider usage of this term than our 'history' naturally follows. The topics can be any singular, non-deducible cases, such as animals in Aristotle's *Historia animalium,* or even nature as a whole, as for Pliny's *Naturalis historia*. Occasionally, Aristotle uses the adverb ἱστορικῶς, denoting something like 'scientifically'.[50] Varro was already clearly aware of this same difference when he compared invented and grammatically derived words (*De lingua latina* VIII.1(6), ed. Goetz & Schoell, p. 126):

> *ad illud genus, quod prius, historia opus est: nisi discend[end]o enim aliter id non pervenit ad nos; ad reliquum genus, quod posterius, ars: ad quam opus est paucis praeceptis quae sunt brevia.*
> 'For that kind [words "invented" by *impositio*], *historia* is required, without learning them they do not reach us; for the other kind, the second one [words derived by *declinatio*], *ars* is required. For this work only few and short rules are required.'[51]

Thus, *historia* treats singular cases, whereas *ars*/*disciplina*/*scientia* is general and rule-based; the *ars* alluded to here is, of course, *ars grammatica*. In early modern times, the difference between apodictic Aristotelian knowledge as *scientia* and more descriptive knowledge as *historia* will continue to be felt: botany and zoology will still be seen as 'natural history', in German as *Naturkunde*,[52] although they de-

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the recounting of deeds (*narratio rei gestae*), and observation of facts. He follows Goclenius, *Lexicon philosophicum* (Francofurti, 1613), p. 626.

48 Aristotle also points out that the καθόλου is missing in ἱστόρια. *Poetica* 9, 1451b5–7, ed. Tarán & Gutas, p. 179: Διὸ καὶ φιλοσοφώτερον καὶ σπουδαιότερον ποίησις ἱστορίας ἐστίν· ἡ μὲν γὰρ ποίησις μᾶλλον τὰ καθόλου, ἡ δ' ἱστορία τὰ καθ' ἕκαστον λέγει ('This is why poetics is more philosophical and serious than history. Poetics relates more the general, history the specific').

49 e.g. von Fritz (1967: 5), who emphasises the critical approach in both. See also von Fritz (1952). See chap. 24 below on whether 'science' is a Greek invention.

50 *De generatione animalium* III.8 (757b35). LSJ translate the adjective as 'exact, precise, scientific'.

51 Thus, Varro would say that in the strife between sound-law Neogrammarians and their opponents with the slogan 'chaque mot a son histoire' ('each word has its own history') both approaches are valid depending on the word. But it seems that Varro (and other premodern authors) rather underestimated the complexity of the rules involved.

52 *Kunde* from Old High German *kundeo* ('witness') denotes a rather wider form of 'testified' knowledge than *Wissenschaft*.

velop as sciences in the modern sense of the word. The Scientific Revolution, however, will mix these two categories again by taking into account observations of unique events ('idiographic science'),[53] from which a science may progress from description to finding underlying patterns and thus become explanatory, as, for instance, happened to botany and zoology with – at the latest – the advent of evolution theory and twentieth-century genetics. In Latin the word *historia* soon also acquires a broader meaning of any 'account, narrative, tale' (whence the English word 'story').[54] The word finally ends up as 'history' in English, again getting closer to Herodotus, who, however, used only one specific nuance of the word, that of the ἱστορία of peoples.

Further complicating things, some later authors see *historia* (in this narrow sense of 'historiography') itself as approaching an *ars*, as does for instance Hugh of St Victor in the twelfth century.[55] Other writers seem to sense a personal, so to speak 'subjective', component (its topic being within us, not in 'external' nature), for instance the fifteenth-century theologian Lambertus de Monte, *Expositio De anima* (Cologne, 1498), fol. 4ra:

> *Notandum, quod Aristoteles vocat hanc scientiam de anima 'historiam' […] quia sicut in historiis traduntur aliqua quae in nobis experimur, ita scientia de anima est de his quae in nobis ita esse naturaliter experiuntur.*
> 'It is to be noted that Aristotle [in 402a4] calls this science of the soul *historia* […] because as in history books things that we experience within us are handed down, so the science of the soul concerns itself with such matters that are naturally experienced within us.'

Historiography was thus often seen as merely rhetorical, literary, or didactic in nature and had no fixed place among the mediaeval sciences.[56] It had its distinctive stylistic ideals, and an oratorial style was expected to be used in writing historiography.[57] But in early modern times, there was a renewed discussion about whether history can be an *ars* or even a *scientia*. One of the authors writing about this topic was Gerardus Johannes Vossius (1577–1649), *Ars historica* 2–4, pp. 5–14, opting for the former:

53 As von Fritz (1967: 3) calls it.

54 Loci in Lewis & Short (s.v.); earliest usages already in Plautus. See also Cizek (1995: 12–13).

55 *Didascalicon* III.2, ed. Offergeld, pp. 216–228. More exactly, he speaks of an *appendens artium*, as it is not part of the traditional seven (see chap. 10 below).

56 More details in Melville (1986–1987: 157–172).

57 e.g. Cicero, *De legibus* I.2(5), ed. Plinval, pp. 3–4: [*historia*] *quippe cum sit opus, ut tibi quidem uideri solet, unum hoc oratorium maxime* ('since as at least you have always held, this endeavour [history] is the most oratorial one').

> *QUam notum est historiae nomen, tam pene ignotum est plurimis, organicam esse disciplinam, quae Historice vocetur. [...] Scientia vero non est, ut tum finis indicat, tum obiectum. Nam historice discitur, ut historiam legitime contexamus; scientia vero est, non operationis, sed sciendi gratia.*
> ‘As well known as the name “history” may be, it is nearly unknown to many that there is also a practical discipline called “historiography” [ἱστορική]. [...] It is not a science, as its aim and its object indicate. For historiography is learned in order that we may compose history books; but a science does not strive after a work, it is for acquiring knowledge only.’[58]

Other authors, such as Sebastiano Maccio (*De historia*, Venetiis, 1613, chap. 10; quoted disapprovingly by Vossius, *Ars historica* 4, p. 17) had indeed gone further in demanding the status of a *scientia* for *historia*. It has been argued that historiography becomes a scientific discipline only in nineteenth-century German *Historismus*,[59] when textual criticism and source criticism were methodologically applied in order to pinpoint historical ‘laws’. Others are of the view that it has never become a scientific field at all. But some writers of Antiquity and the Middle Ages were well aware that scientific principles could be applied even to matters that happen only once and belong to historiography in the modern sense, with the aim of reaching the best possible understanding of what happened. More ambitious authors in the antique tradition of great historians, from Hecataeus (fl. 500 BC) and Herodotus (ca. 484–ca. 425) to Thucydides (ca. 460–ca. 400) and Polybius (ca. 200–ca. 118) or Titus Livius (64/59 BC–AD 17) and Cornelius Tacitus (ca. 56–after 117) did – often successfully – look for deeper reasons behind historical developments, and they did think critically and understood motivating forces behind events, all of which led to a deeper understanding of historical events. How good, scientific historiography is to be done is already pointed out in detail by Lucian (*Quomodo historia conscribenda sit* 47–48, ed. MacLeod, vol. 3, p. 314):[60]

> Τὰ δὲ πράγματα αὐτὰ οὐχ ὡς ἔτυχε συνακτέον, ἀλλὰ φιλοπόνως καὶ ταλαιπώρως πολλάκις περὶ τῶν αὐτῶν ἀνακρίναντα, καὶ μάλιστα μὲν παρόντα καὶ ἐφορῶντα, εἰ δὲ μή, τοῖς ἀδεκαστότερον ἐξηγουμένοις προσέχοντα καὶ οὓς εἰκάσειεν ἄν τις ἥκιστα πρὸς χάριν ἢ ἀπέχθειαν ἀφαιρήσειν ἢ προσθήσειν τοῖς γεγονόσιν. κἀνταῦθα ἤδη καὶ στοχαστικός τις καὶ συνθετικὸς τοῦ πιθανωτέρου ἔστω. καὶ ἐπειδὰν ἀθροίσῃ ἅπαντα ἢ τὰ πλεῖστα, πρῶτα μὲν ὑπόμνημά τι συνυφαινέτω αὐτῶν καὶ σῶμα ποιείτω ἀκαλλὲς ἔτι καὶ ἀδιάρθρωτον· εἶτα ἐπιθεὶς τὴν τάξιν ἐπαγέτω τὸ κάλλος καὶ χρωννύτω τῇ λέξει καὶ σχηματιζέτω καὶ ῥυθμιζέτω.

58 Vossius thus applies the standard distinction between *ars* and *scientia*. For the general (widespread) discussion on the nature of *historia* in early modern times, see Grafton (2007).
59 e.g. by Korenjak (2016: 199).
60 On *historia* as a methodological science in the Middle Ages, see Schulz (1909), who shows that all of the points mentioned by Lucian were reiterated by mediaeval historians; on *historia*’s relation to the Liberal Arts, see Wolter (1976).

'The facts should not be assembled at random, but he [the historian] must examine them painstakingly and often in a manner full of hardship, and if possible be an eye-witness and observe. If he cannot, he should heed the more impartial witnesses and those who would least seem to leave aside or add facts out of favour or malice. Then he should be shrewd and skilful in composing a story as plausible as possible. When he has assembled all or most of the data, he should first compose notes from them and he should make a body of material as yet unadorned and without organisation. Only then, after arranging it in an orderly manner, he should adduce beauty and adorn it with phrasing and figures and rhythm.'

In brief, this is what Polybius called ἀποδεικτικὴ ἱστορία[61] and can be rendered as 'scientific historiography'. The Middle Ages and early modern times also had historians who worked very much according to such principles, for instance William of Malmesbury (ca. 1095–ca. 1143), whereas other historians (e.g. Liutprand of Cremona, ca. 920–972) instead wrote propagandistic history that clearly took sides. In general, indeed, it was only in the nineteenth century that scientific rigour and clearly defined methods became standard for historiography, which was now present as a discipline at universities, but many other sciences became much more rigorous during or after the Scientific Revolution too.[62] Introductions to history's methodology often concluded that history was indeed a science. For instance, Feder (1924: 12–14) argues that historiography is a science despite Aristotle's insistence that sciences treat only 'das Allgemeine' ('the general'; 12), for it seeks a genetic and causal understanding of the past. Boyer sums the discussion up (*Cursus philosophiae*, *Logica maior* q. 4, a. 4, §1.II, vol. 1, p. 295):

De alia quaestione, minoris quidem momenti, an scilicet historia sit proprie scientia, alii aliter opinantur.
'On this other question, which is of lesser moment, whether historiography is a proper science, some think this and some that.'

Even though there would thus seem to exist quite strong arguments for including historiography among the sciences, it is only marginally treated in this book, as it differs conspicuously in several respects from other sciences, among them in its language, as a sample of texts below (chap. 20) will show. Indeed, as the quoted passages have suggested, even in Antiquity historiography had its own style, quite in contrast to most other scientific disciplines. In Antiquity and the Middle

61 *Historiae* II.37, ed. Büttner-Wobst, vol. 1, p. 169.
62 Châtelet is thus too sweeping when he states: 'L'histoire est savoir. Elle n'est savoir historique – on veut dire par là: savoir qui a la possibilité d'apporter les preuves de sa véracité – que depuis le xix^e siècle' ('History is knowledge. It is only since the nineteenth century that it has been historical knowledge – by which we mean knowledge that entails the possibility of adducing proofs of its veracity'; 1962: 15).

Ages, the connection between *scientia*/*disciplina* and *historia* is rarely pointed out explicitly.

φιλοσοφία – *philosophia* (*amor sapientiae*)

§6 This word describes what the φιλόσοφος (‘lover of wisdom’) does. It was apparently coined by – according to non-contemporary ancient sources – Pythagoras, as a more modest term than ὁ σοφός (‘the wise man’).[63] The Romans loaned the Greek word as *philosophia*, only rarely[64] translating it as *amor sapientiae*. One might be tempted to see a development from ‘wise men’ through philosophers to scientists, but, reality is – as so often – rather more complicated. Only some general points about the complicated epistemological question of the shifting relation between philosophy and science can be discussed here. It is clear that this relation changed over time and that there are several mutually exclusive positions. For Aristotle, φιλοσοφία and ἐπιστήμη largely overlap; indeed, Bonitz (s.v. φιλοσοφία) explains the former as *investigatio; scientia, cognitio; philosophia*. Aristotle distinguishes a first and a second philosophy, the former what we would call metaphysics today, the latter roughly natural science (*Metaphysica* Z11, 1037a13–20): studying things that can be perceived by the senses. In Antiquity φιλοσοφία was usually a more global concept comprising and sometimes emphasising the more ‘practical’ and global connotations of the philosophers’ own way of being (especially among Stoics),[65] whereas ἐπιστήμη was a more exclusively theoretical endeavour divided into various disciplines. Among the Roman philosophical schools, especially the Stoics, it was customary to divide philosophy into three disciplines: physics, logic, and ethics. The first of them corresponds more or less to our natural science, but the last of them was by far the most esteemed one.[66] In Roman times, the term *philosophus* was often used as an honorific for

63 Diogenes Laertius, *De vita philosophorum* I.12, ed. Long, vol. 1, p. 5, and Cicero, *Tusculanae disputationes* V.3(8–9), ed. Fohlen, pp. 109–111, who translates the concept as *sapientiae studiosus*. See further Burkert (1960).

64 e.g. Augustine, *De ordine* I.32, ed. Doignon p. 156.

65 ‘[I]l est utile de rappeler le sens “totalitaire” de la “philosophie” chez tous les penseur païens: la philosophie est pour eux la synthèse du savoir, le système général des sciences, la sagesse intégrale vers laquelle est bandé tout l’effort de la pensée humaine’ (‘It is useful to recall the “totalitarian” sense of “philosophy” in all pagan thinkers: for them, philosophy is the synthesis of knowledge, the general system of sciences, the integral wisdom to which all the effort of human thought is directed’; van Steenberghen 1966: 55).

66 The three parts of philosophy, e.g. in Zeno of Citium §45, ed. von Arnim, vol. 1, p. 15 (= Diogenes Laertius, *De vita philosophorum* VII.39, ed. Long, vol. 2, p. 314): τριμερῆ φασὶν εἶναι τὸν κατὰ φιλοσοφίαν λόγον. εἶναι γὰρ αὐτοῦ τὸ μέν τι φυσικόν· τὸ δὲ ἠθικόν· τὸ δὲ λογικόν. οὕτω δὲ men of letters holding some important public office and usually pertaining at least loosely to one of the philosophical schools.[67] On the other hand, the polysemous word ἐπιστήμη can also denote the philosopher's approach to gaining wisdom and knowledge. In either case, φιλοσοφία will comprise ἐπιστήμη.[68] However, on the other hand, *philosophia sensu stricto* can be seen as a scientific discipline, as is often the case today.[69] Thus, *philosophia* can be seen as an *ars*[70] or a *scientia*. Thomas Aquinas states in his *Sententia libri Metaphysicae* (IV.4.7, ed. Spiazzi, p. 574):

> *Licet autem dicatur quod philosophia est scientia, non autem dialectica et sophistica, non tamen per hoc removetur quin dialectica et sophistica sint scientiae.*
> 'Although it may be said that philosophy is a science, not so dialectic and sophistic, although by this it will not be denied that dialectic and sophistic can be sciences. [He goes on to state in what way the latter two can also be considered *scientiae*.]'

Even in the twentieth century, the neo-scholastic *Cursus philosophiae* by Carolus Boyer still presents the following definition (*Introductio* 2, a. 2, vol. 1, p. 46):

> *[P]hilosophiae definitio, quae communiter recipitur: Scientia rerum per ultimas causas naturali rationis lumine comparata.*
> 'The definition of philosophy that is commonly used: the knowledge [*scientia*] of things through their highest causes, attained by natural reason.'[71]

A possible precursor to this point of view can be seen in Isidore, for whom *philosophia* is the culmination of science (*Etymologiae* II.24.9, ed. Marshall p. 107; see chap. 2 §4 above):

πρῶτος διεῖλε Ζήνων ὁ Κιτιεὺς ἐν τῷ περὶ λόγου ('It is said that the philosophical logos is threefold. It contains physics, ethics, logic. Zeno of Citium first made this distinction in his work *On the Logos*').

67 Haake (2017) studies the use of *philosophus* on Roman inscriptions. He finds the term as an honorific much more commonly in the Eastern, Greek, part of the Empire, where the polis structure, seen by Haake as the natural habitat of the philosopher (413), was still partly intact. Interesting statistical research on these schools has been performed by Goulet (2017).

68 See Hadot (1979).

69 Compare the list of sciences drawn from Schurz in chap. 1 §7, which includes philosophy.

70 Thus Seneca, *Naturales quaestiones* I, proem., ed. Hine, p. 1: *Quantum inter philosophiam interest, Lucili uirorum optime, et ceteras artes, [...]* ('As much as there is difference within philosophy, Lucilius, best of men, and within other arts [...]').

71 The addition 'natural' is meant to distinguish it from theology. Similarly *Cursus philosophiae,* Intro. 2, a. 2, §2.I, vol. 1, p. 48: *Philosophia cum ceteris scientiis convenit in quantum et ipsa est vera scientia, scilicet ordinatur ad cognitionem certam obtinendam, de qua rationem reddere possit ('Philosophy accords with other sciences in that it too is a true science, viz. it is disposed toward the attainment of certain knowledge for which it can provide the reason'*).

> *Philosophia est ars artium, et disciplina disciplinarum.*
> 'Philosophy is the art of arts, the science of sciences.'

Although the Greeks did not keep what we now call 'philosophy' and 'science' neatly apart, already around 500 BC there were men who engaged exclusively in the one or the other – exclusively philosophers (e.g. Heraclitus or Zeno) and exclusively scientists/scholars (Hecataeos of Miletus, Hippocrates of Chios, Theaetetus). Of course, some also did both, such as Parmenides, Democritus, and, later on, Aristotle.

Derived from the Stoic *physica*, natural science was often called *naturalis philosophia* in the Middle Ages and early modern times instead of *naturalis scientia*.[72] Among Epicureans, the term φυσιολογία, taken over by Cicero as *physiologia*, was used in the same sense. In fact, traces of this view were to remain in place until recently: German-speaking universities housed the natural sciences in a *Philosophische Fakultät II* (adding the number 'II' to differentiate from the human sciences and philosophy proper).[73]

The definite division between natural science and philosophy takes place as late as in the eighteenth and nineteenth century; Wilhelm Dilthey (1833–1911), in particular, builds the foundation for a new, narrower meaning of philosophy.[74] In the wake of the great successes of the 'hard' sciences since the Scientific Revolution (see chap. 12 below), some polemical scientists have insisted that philosophy is not a scientific enterprise at all and concluded that it is therefore of little value.[75] Paulsen (1877: 35) formulates this point especially drastically by comparing philosophy metaphorically to idlers and robbers:

72 Corpus Corporum (as of 1 March 2016) has 24 occurrences of the former versus 40 of the latter before Aquinas, and 133 and 347 before AD 1600. Thus, *naturalis philosophia* is losing ground in the Late Middle Ages. There seems to be an increased awareness of *scientia* as distinct from *philosophia*.

73 This name persists to this day at some universities, such as the Humboldt University in Berlin.

74 See further Wieland (1970: 16).

75 For instance, Zhmud, writing on this topic, does not define what he means exactly by philosophy and science; he just states an 'epistemologische Andersartigkeit [...], wissenschaftliche Probleme können erfolgreich gelöst werden, philosophische Probleme sind prinzipiell unlösbar' ('epistemological difference [...], scientific problems can be solved successfully, philosophical problems are unsolvable in principle'; 1994: 1). Zhmud seems to take philosophy mostly as metaphysics, which in turn he sees as a kind of depersonalised mythology, leading to famous 'pre-Socratic' statements that everything is water or fire or infinity. His disdain of philosophy on the one hand and his approval for practically applicable science on the other may be connected with his materialist Soviet background. In other publications, he shows a general scorn for myth and religion.

> So möge sie in ähnlicher Weise der Wissenschaft vorausgehen, wie etwa Räuber und allerlei Arbeit und Ordnung hassendes Gesindel in Amerika als Pioniere der Zivilisation dem Ackerbauer und Städtegründer vorangehen.
> 'It [philosophy] may precede science similarly to how robbers and all kinds of work- and order-hating rabble precede the farmers and founders of cities as pioneers of civilisation in America.'

Others emphasise today the personal character of philosophy in improving the philosopher, or see it as a human science.

παιδεία, παίδευσις – *eruditio*

§7 Although παιδεία can be translated as *eruditio* in Latin,[76] there is no direct correspondence for these words. In Greek παιδεία,[77] παίδευμα, and παίδευσις are similar terms, all of them meaning literally 'what is done with the young (in order to cultivate them)'. The first denotes the entire process and the resulting state, the second that which is taught in order to reach it, and the third the action and means of achieving it. The Latin term *eruditio* is similar in meaning, although it looks at the situation from the result *ex negativo*: literally as 'de-savagisation'. All of these terms emphasise more the state of education one attains through learning than science proper. For Aristotle, mere general education (παιδεία) is a kind of condition (τρόπος τῆς ἕξεως; *De partibus animalium* I.1, 639a1–4) different from the scientist's in-depth study (ἐπιστήμη):

> Περὶ πᾶσαν θεωρίαν τε καὶ μέθοδον, ὁμοίως ταπεινοτέραν τε καὶ τιμιωτέραν, δύο φαίνονται τρόποι τῆς ἕξεως εἶναι, ὧν τὴν μὲν ἐπιστήμην τοῦ πράγματος καλῶς ἔχει προσαγορεύειν, τὴν δ' οἷον παιδείαν τινά.
> 'For all theoretical and methodological endeavours, be they humbler or worthier, there seem to be two kinds of conditions. The one may rightly be called a scientific knowledge of a thing, the other [merely] like education.'

This παιδεία – although not reaching scientific standards – is still addressed as a θεωρία and μέθοδος to gain insight. It is reserved for free men, as is stressed in *Politica* VIII.3, 1338a:

> ὅτι μὲν τοίνυν ἔστι παιδεία τις, ἣν οὐχ ὡς χρησίμην παιδευτέον τοὺς υἱεῖς οὐδ' ὡς ἀναγκαίαν ἀλλ' ὡς ἐλευθέριον καὶ καλήν, φανερόν ἐστιν.

76 Hedericus & Pitzger (s.v. παιδεία) offer as translations: *institutio, instituendi ratio, doctrina, eruditio, disciplina*, whereas they translate παίδευσις as *ipsa erudiendi actio*.
77 On this important concept, see the classic Jaeger (1934) and more recently Kühnert (1961).

> 'It is clear that there exists some kind of education which is not taught as practically useful to sons, not as necessary, but as something free and beautiful.'

It will become clear in chapter 9 below how this παιδεία gave rise to the expression ἐγκύκλιος παιδεία – approximately 'education in all the circles of disciplines' – and would in turn lead to the genre of natural histories and finally to the 'encyclopaedia'. Its canon led to the *artes liberales,* which are, again, reserved for free men.

διδασκαλία – *doctrina*

§8 *Doctrina* is the term often used for the teaching of science and other learning. The word – derived from *doceo* ('to teach') – corresponds to διδασκαλία ('learning'), which is likewise derived from the word for 'to teach' (διδάσκω).[78] Semantically similar words in German are *Lehre* and *Gelehrsamkeit*, or English 'learning' These words tend to be used for the more or less dogmatic content taught to pupils which can become the foundation on which to build further scientific studies. In pagan Antiquity the word's semantics already at times approach our 'science', for instance in Pliny, *Naturalis historia* (VIII.17(44), ed. Ernout et al., vol. 8, p. 38):

> *Alexandro Magno rege inflammato cupidine animalium naturas noscendi delegataque hac commentatione Aristoteli, summo in omni doctrina viro, aliquot milia hominum in totius Asiae Graeciaeque tractu parere iussa, omnium quos venatus, aucupia piscatusque alebant quibusque vivaria, armenta, alvaria, pisciniae, aviaria in cura erant, ne quid usque genitum ignoraretur ab eo.*
> 'King Alexander the Great, who was inflamed with a desire to know the natures of animals, assigned this study to Aristotle, the greatest man in every science. He placed thousands of men in every region of Asia and Greece under his command, comprising all those who are nourished by hunting, fowling, or fishing, or who had the care of parks, herds of cattle, the breeding of bees, fish-ponds, and aviaries, in order that he should not miss any such matter.'

The twelfth-century translator James of Venice, who translates Greek *verbum de verbo,* translates the beginning of Aristotle's *Analytica posteriora* as (ed. in *Aristoteles Latinus* 4.1–4, p. 5):

> Πᾶσα διδασκαλία καὶ πᾶσα μάθησις διανοητικὴ ἐκ προϋπαρχούσης γίνεται γνώσεως.
> *Omnis doctrina et omnis disciplina intellectiva ex praeexistente fit cognitione.*
> 'All scientific learning and all theoretical science departs from already existing knowledge.'

78 This is an interesting case in which the semantic and etymological correspondences differ: etymologically *doceo* = δοκέω, *disco* (< **di-dḱ-sḱ-ō*) = διδάσκω (see *LIV*, which, however, proposes a desiderative form of the same root, **di-dḱ-se-*).

This equates *doctrina* with διδασκαλία and *disciplina* with μάθησις. Isidore, on the other hand, brings *mathematica* (and thus μάθημα) close to *doctrina* when he equates it with *doctrinalis scientia* (*Etymologiae* III, praef., ed. Gasparotto, p. 3),[79] in a passage inspired by Cassiodorus:[80]

> Mathematica latine dicitur doctrinalis scientia quae abstractam considerat quantitatem.
> '*Mathematica* means in Latin the scientific teaching which considers abstract quantity.'

This usage is occasionally also met later on, as in the twelfth-century *al-Fārābī Latinus*.[81] In both cases, *doctrina* conveys knowledge that is taught and learned. In the Early Middle Ages, when the school aspect of learning becomes central, this term is often used in a sense that approaches that of *scientia*/*disciplina*. The PL, with its nearly exclusively late antique and mediaeval Christian texts, contains 197 cases of synonymous use of the kind *scientia et*/*ac*/*atque doctrina* (or vice versa, in all case-forms). There are only 30 such cases for *ars* and *scientia*, and even for the near-synonyms *disciplina* and *scientia* only 119. In the later Middle Ages, *sacra doctrina* was to become a common designation for the 'sacred science' of theology.

Σπουδή and μελέτη in Greek and *studium* in Latin belong to the same semantic province, although these terms are broader. For example, Pliny calls the Numidian King Iuba (*Naturalis historia* V.1.16, ed. Ernout et al., vol. 5, p. 52) *studiorum claritate memorabilior etiam quam regno* ('even more memorable by the fame of his scientific studies than as a king'). Georges defines this use as 'das wissenschaftliche Streben, die wissenschaftliche Beschäftigung, das Studieren' ('scientific pursuit, scientific occupation, study'). Of course, *studium* has a broad spectrum of meaning, more usually of any 'striving' after something.

μέθοδος – *methodus*

§9 Another Greek word that was taken over into Latin as a loanword (like *historia* and *philosophia*, encountered above) is μέθοδος. This Greek word is derived from

79 The theoretically more fitting *disciplinaris*/*disciplinalis* is very rare before the High Middle Ages. Occasionally, *disciplinaliter* is used to translate ἐπιστημονικῶς (e.g. several times by Eriugena). Another late word for 'scientifically' is *scientifice,* mentioned in §3 above.

80 Cassiodorus, *Institutiones* II.3.21, ed. Mynors, p. 130: *Mathematica, quam Latine possumus dicere 'doctrinalem', scientia est quae abstractam considerat quantitatem* ('Mathematics, which we can call *doctrinalis* in Latin, is the science that considers abstract quantity').

81 Translation by Dominicus Gundissalvi, prol., ed. Schneider, p. 120. Alongside the four usual sciences of the *quadrivium,* al-Fārābī adds further mathematical sciences: optics, mechanics, and statics. On this author, see further chap. 10 §6 below.

ὁδός ('path'), with the preverb μετα-, and means 'pursuit of knowledge, investigation'. Its use for a pursuit of other things than knowledge and science is very rare.[82] Later on, in a clearly derivative way, the word can be used as 'ruse, trick', as in the Septuagint Bible (2 Macc. 13:18). Plato uses the word 26 times, Aristotle 79 times. Bonitz explains Aristotle's usage as *via ac ratio inquirendi;* in fact, Aristotle himself seems to paraphrase the word as 'the way of searching': τῆς ζητήσεως ὁ τρόπος (*Analytica priora* I.31, 46b36). Later times see derivative words such as μεθοδεύω ('treat or practise by rule or method'; explained by Hesychius, ed. Latte, s.v., as μετέρχεσθαι) or μεθοδεία ('craft, wiliness; method of collecting taxes or debts'). Μέθοδος becomes one of the ways of expressing 'science' in Roman Antiquity, especially when wishing to stress its systematic character. For example, Nicomachus of Gerasa (*Introductio arithmetica* 1.1, ed. Hoche, p. 1) writes (meaning men like Pythagoras):

> Οἱ παλαιοὶ καὶ πρῶτοι μεθοδεύσαντες ἐπιστήμην [...].
> 'The ancients who first made knowledge systematic/scientific [...].'

A similar usage is found in Galen. He posits λόγος and πεῖρα as the instruments of science, which he calls λογική μέθοδος.[83]

The first author we know of who used the word in Latin is Vitruvius.[84] Latin finds a similar word in *procedura* only very late, by borrowing it back from French.[85] It usually remained confined to legal procedures. In Roman times, there is a medical school called the *methodici* (μεθοδικοί),[86] which Celsus calls *quidam medici saeculi nostri* ('certain physicians of our century'; *De medicina* 1, prol. 54, ed. Marx, p. 26). They arose as a reaction against and a mediation between the *empirici* and the *dogmatici*.[87] Celsus describes their undogmatic 'method' thus:

> *contendunt nullius causae notitiam quicquam ad curationes pertinere; satisque esse quaedam communia morborum intueri.*

82 Pape defines it as 'das Nachgehen, Verfolgen; wohl nur vom kunstgemäßen, wissenschaftlichen Verfolgen einer Idee, von der wissenschaftlichen Behandlung eines Gegenstandes, u. bes. das geregelte Verfahren dabei, die Methode' ('following, pursuit; probably only for the artistic, scientific pursuit of an idea, for the scientific treatment of an object, and in particular the regulated procedure involved, the method'; s.v. μέθοδος). LSJ (s.v.) does have a few examples of the pursuit of other things, such as νύμφης μέθοδον ποιεῖσθαι ('pursuit of a maiden'; an anonymous quotation in the Suda lexicon, s.v. ζεῦγος).
83 *De methodo medendi* I.8, ed. Kühn, vol. 10, p. 29.
84 *De architectura* I.1.4, ed. Fensterbusch, p. 24.
85 There are two instances, both from the eighteenth century, in Corpus Corporum.
86 On them, including a collection of their fragments, see Tecusan (2004).
87 On the methodologies of these three schools, see Lloyd (1987: 158–167).

> ‘they contend that no knowledge of the [ultimate] cause [of a disease] should have influence on cures; and that it is enough to consider some common features of diseases.’

Themison of Laodicea (123–43 BC) seems to have founded this school. Caelius Aurelianus calls it the *methodica disciplina*.[88] This school’s name will be the most common use of the word *methodus*, which otherwise remains quite in the background, at least until modern discussions of ‘methodology’ (note the sharp rise in early modern times in table 2 below).

§10 In order to find out how common the terms considered are in literature in general through the ages, their absolute frequency per thousand words and their frequency classes were determined in table 2 and illustrated in figure 2. The values for the frequency classes are logarithmic, and low ones entail high frequency.[89] The numbers were calculated using Corpus Corporum for lemmata in five important time spans;[90] numbers for the tentative Greek equivalents are also provided, for Greek as a whole (*TLG*) and for Aristotle, an author who seems especially important for scientific terminology. The most common lemma, which is assigned frequency class 0, is given at the bottom; either *sum* or *et* tend to be the most common.

There are obviously significant differences between Greek and Latin usage as well as within these languages. The frequency classes for these words are two to three classes more common in Latin than in Greek. This may partly be explained by the absence in Latin of the most common Greek word: the article, which is (per thousand words) much more common than the most common Latin word. The absolute values in Latin still tend to be slightly higher than the corresponding ones in Greek.

88 Caelius Aurelianus, *Tardae passiones* IV.1.6, ed. Drabkin, p. 816.
89 More precisely, frequency classes are a binary measure of how much less often a word occurs than the most frequent word in a language. Thus, a word (say) 16 times (= 2^4) less frequent than the most common one in the language in question belongs to class 4. The precise formula is: cl(#word) = FLOOR [0.5 − $\log_2$(f(#word)/f(#most frequent word))]. More details in e.g. Meier (1978).
90 The same samples were used for the benchmark corpora below (chap. 18 §2). See there for details on them.

Table 2: Absolute values in ‰ and frequency classes of key terms for ‘science’ in general Latin samples from various periods. The values for similar Greek words in general and in Aristotle are given for comparison.

	100 BC–AD 200		200–450		780–900		1100–1220		1500–1820		Greek	*TLG*[91]		Aristotle	
scientia	0.19	8	0.30	7	0.36	7	0.39	7	0.24	7	ἐπιστήμη	0.18	10	0.85	7
disciplina	0.23	7	0.22	8	0.19	8	0.17	8	0.08	9	μάθημα	0.05	12	0.02	13
ars	0.41	7	0.09	9	0.08	9	0.07	9	0.15	8	τέχνη	0.24	9	0.27	9
historia	0.13	8	0.10	9	0.18	8	0.11	9	0.24	7	ἱστορία	0.12	10	0.03	12
philosophia	0.21	8	0.05	10	0.02	11	0.03	11	0.11	8	φιλοσοφία	0.11	10	0.06	11
doctrina	0.13	8	0.31	7	0.47	6	0.31	7	0.65	6	διδασκαλία	0.13	10	0.02	13
eruditio	0.02	11	0.03	11	0.03	10	0.03	11	0.03	10	παιδεία	0.06	11	0.08	11
methodus	0.00	14	0.00	17	0.00	16	0.00	16	0.05	10	μέθοδος	0.05	11	0.07	11
Most frequent	*sum*		*sum*		*sum*		*et*		*et*			ὁ[92]		ὁ	
Total	1.34		1.09		1.34		1.11		1.55			0.92		1.41	

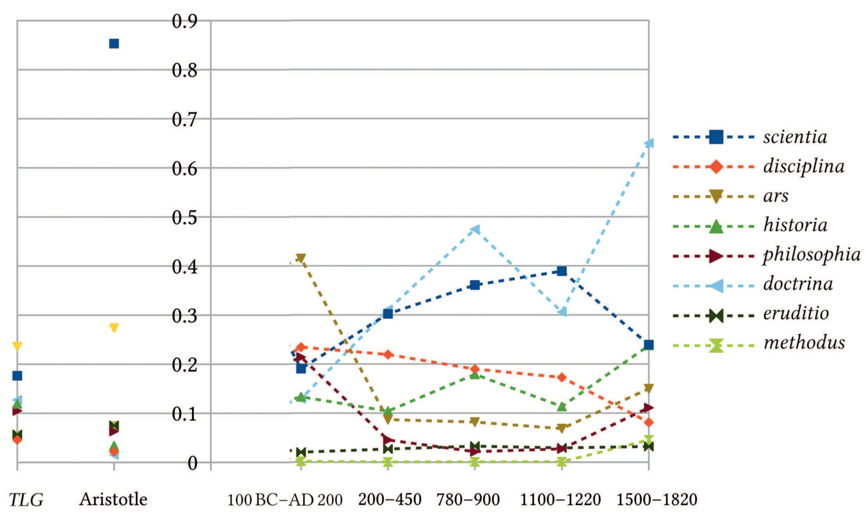

Fig. 2: Distribution of key terms for ‘science’ in Greek (left) and Latin (right) in ‰. For the Greek terms compared on the left-hand side, see table 2.

91 *TLG* does not allow time-constrained searches, so only global numbers were used. The numbers for Aristotle are from Corpus Corporum.

92 The most frequent Greek word is the article, which is lacking in Latin (15.5 million in the entire online *TLG* as of January 2016), followed by καί (6.1 million), δέ (2.1 million), and εἰμί (1.8 million).

Aristotle, whose importance for the further development of Latin scientific vocabulary will become amply clear in chapter 7, uses only ἐπιστήμη and μέθοδος significantly more frequently than the Greek average; most of the other words he even uses less often. The term ἐπιστήμη is clearly very important to Aristotle. In Latin, *ars* is in Antiquity by far the most common of the studied words; *scientia* and *doctrina* become more common over time, the former reaching Aristotle's frequency class early on, but, strangely, its frequency drops again in the sample from early modern times; in contrast, *historia* becomes more common. The frequency of *disciplina* stays relatively constant, though in decline. It can be observed that the early modern frequencies are again closing in on the classical ones, in some cases showing these authors' conscious *imitatio* of Antiquity (*philosophia, ars, scientia*). The Greek loan *methodus* becomes nearly as common as in Aristotle in early modern times after having previously been rare. If the numbers of all these words are added up, a rather stable value between 1‰ and 1.5‰ is reached. The core scientific and scholarly terms seem to remain of constant and high importance across more than two thousand years.

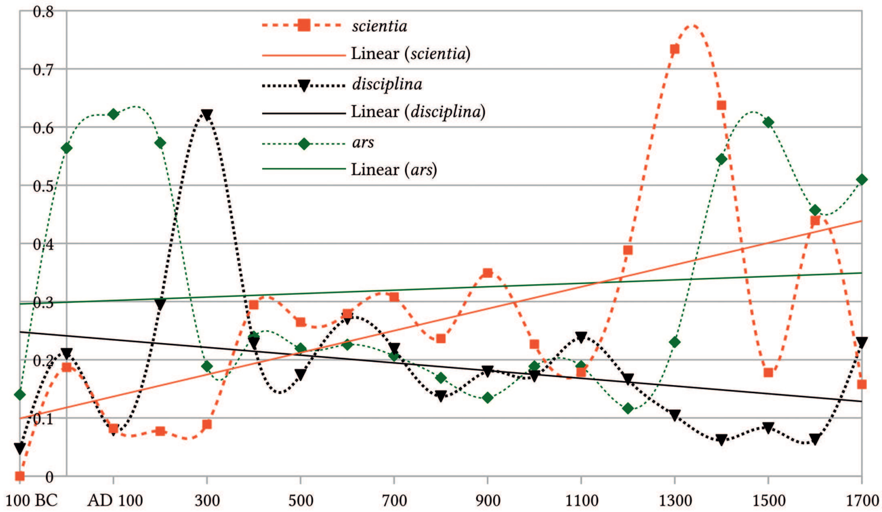

Fig. 3: The lemmata *scientia*, *ars*, *disciplina* in ‰ for the 163 million words of all the texts in Corpus Corporum (as of November 2019), per century. The value at 200, for example, is the sum of all instances in authors who died (or, if unknown, *floruerunt*) between AD 101 and 200. Linear regression trend lines are added for the three words. Dotted lines are polynomial best-fits; they illustrate rather strong fluctuation likely caused by the heterogenic source texts.

In order to gain more precise values for the three most central lemmata for 'science' in Latin (*scientia, ars, disciplina*), occurrences per thousand words for all texts in Corpus Corporum are plotted diachronically in figure 3. As all meanings of the three words are counted in the plot, it may be better to refrain from drawing overly ambitious conclusions. Nonetheless, it would seem that the importance of the term *scientia* already overtakes that of *disciplina* in Late Antiquity,[93] and that of *ars* (think of *artes liberales*) in the twelfth century, as the trend lines nicely hint.

The corpus of Croatian Latin used for early modern times in table 2 may have a humanist belles-lettres bias. In early modern times – during the Scientific Revolution – the word *scientia* hardly declined in popularity. Other data will be biased too; for instance, the numerous works by Thomas Aquinas are responsible for the huge peak of *scientia* in figure 3; indeed, the authors and texts were not selected according to any methodological principle. Nonetheless, it seems clear that *scientia* becomes the most frequent of these terms as time advances and that its frequency rose in Late Antiquity and again in scholasticism, and possibly again at the end of the Middle Ages. Indeed, its linear trend line[94] in the illustration more than quadruples during the 1,800 years depicted, in contrast to the other two words, whose trend lines remain more or less constant or even fall.

§11 In order to understand a semantic field fully, more than a look at near-synonyms is necessary. We now widen the scope and sketch a further circle of words involved in this semantic field. The relationship between the key terms will be studied further in chapter 5. Many of the terms that came to be connected more loosely to the semantic field of 'science' are defined by Aristotle in his book of definitions (*Metaphysica* Δ): ἀρχή, αἴτιον, στοιχεῖον, φύσις, ἀναγκαῖον, ἕν, ὄν, οὐσία, ταὐτά, ἀντικείμενα, πρότερα καὶ ὕστερα, δύναμις, ποσόν, ποιόν, πρός τι, τέλειον, πέρας, καθ' ὅ, διάθεσις, ἕξις, πάθος, στέρησις, ἔχειν, ἔκ τινος, μέρος, ὅλον, κολοβόν, γένος, ψεῦδος, συμβεβηκός. Many of them are key concepts for Aristotle's way of practising science and philosophy, and will remain very important for two millennia. Other important concepts could include θεωρία (*contemplatio, speculatio*) – opposed to πρᾶξις (*praxis, actio*), which roughly demarcates *scientia* from the 'practical' *artes* – δύναμις (*facultas, vis, virtus*),[95] or ὅρος (*definitio*). This last term was formalised and emphasised by Aristotle as fundamental for ensuring that people are speaking about the same thing. He claims that Socrates was the first to use strict definitions.[96] Much further Greek scientific terminology was bor-

93 The peak exhibited by *disciplina* in the third century is mostly due to Tertullian.
94 Linear regression with ordinary least squares was used. Of course, the data does not have to be linear at all, but the line still illustrates the overall growth.
95 For Plato see Souilhé (1919).
96 *Metaphysica* M3, 1078b.

rowed from legal terminology, which, just like science, had to use proof and logical argumentation.

- αἰτία/αἴτιον,[97] πρόφασις[98] (*causa*), still also the legal 'cause' today. It may be noted that in Antiquity the concepts 'cause' and 'reason' are not separated.
- ἀπόδειξις (*demonstratio*): among orators such as Antiphon, ἀποδείκνυμι and ἐπιδείκνυμι are used to show that a case is sufficiently established (Lloyd 1979: 102). In geometry γράφειν ('constructing') may also be used for 'to prove' (Lloyd 1979: 106); in jurisprudence it means 'to indict'.
- ἔλεγχος (*argumentum, indicium*): 'cross-examination' becomes 'scientific proof'.
- λόγον διδόναι (*reddere rationem*) 'was used particularly of rendering a financial account' (Lloyd 1979: 253), until Plato, for whom it means 'to give a (philosophical, scientific) account of a phenomenon'.[99]
- μαρτύριον, μαρτυρέω (*testis, testor*), 'witness', is quite often used by Aristotle (about 66 times), for instance: μαρτύριον τῶν εἰρημένων ἡμῖν λόγων ('witness of what we have said'; *De caelo* II.9, 291a7).
- νόμος (*lex*), which will become 'law of nature' among the Stoics, who coin the concept of νόμοι φύσεως (*leges naturales*) that will become fundamental in early modern times. Its first surviving occurrences are in Philon of Alexandria. In classical times, φύσις and νόμος were strict contrasts.[100]
- οὐσία (*essentia*, *substantia*), as 'one's substance, property' = ἅ τινι ἔστιν, will be the word of choice for Plato and Aristotle for 'stable being', which in some sense takes over or refines the earlier concept of φύσις. Defined in *Metaphysica* Δ8, 1017b.
- πρᾶγμα (*res*) 'business, esp. law-business', another term that will remain important in various circumstances, eventually leading to *realitas* (a common word in Neo-Latin philosophy)[101] and our 'reality'.
- ὑπόθεσις (*suppositio*), also 'law case, lawsuit'.

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97 Lloyd (1987: 290), offers a list of its use in Hippocratic writers, where the meaning 'blame' is often still present, too.

98 Used thus in the Hippocratic *De morbo*.

99 e.g. *Theaetetus* 202c: τὸν γὰρ μὴ δυνάμενον δοῦναί τε καὶ δέξασθαι λόγον ἀνεπιστήμονα εἶναι περὶ τούτου ('He who cannot give and display an account lacks knowledge about a subject').

100 Kullmann (2010) shows that the concept of law of nature exists already in Antiquity, especially in Stoicism. Augustine, *De Genesi ad litteram libri duodecim* 9.§17, ed. Zycha, p. 291, says: *Omnis iste naturae usitatissimus cursus habet quasdam naturales leges suas* ('This entire familiar course of nature follows certain natural laws of its own').

101 Although already common in Duns Scotus, other authors who use it often are Francisco Suárez, Spinoza, and Descartes.

Besides this strikingly legal terminology, which may have found its way into the philosophy of Socrates' pupils through sophists, who were very much interested in legal matters, there is the idea of nature as a craftsman.[102] Thus, terms such as ἐμπειρία (*experientia*)[103] or *peritia* are often encountered in the ambit of 'science'. The craftsman god fashioning the material world in Plato's *Timaeus* is a famous case. Some other Greek words that have been crucial in philosophy and science stem from or received a decisive twist in their meaning from the ancient 'sages'. Examples are στοιχεῖον[104] (*elementum*); φύσις[105] (*natura*); or λόγος (*ratio* and *sermo*),[106] which we encountered above (introduction §2) as a hardly translatable Greek term. In *Thaetetus*, Plato tries to find the precise meaning of λόγος (from 206c onward)[107] and finds three meanings: 'word', a more mathematical one close to 'ratio', and 'distinguishing mark or token' of something (thus coming close to 'definition'). This last meaning of a thing's λόγος as its *definiens* is then chosen as the appropriate one for philosophy; it enables a 'scientific' grasping of something (208e):

> Ὃς δ' ἂν μετ' ὀρθῆς δόξης περὶ ὁτουοῦν τῶν ὄντων τὴν διαφορὰν τῶν ἄλλων προσλάβῃ, αὐτοῦ ἐπιστήμων γεγονὼς ἔσται οὗ πρότερον ἦν δοξαστής.

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102 On which see Solmsen (1963).

103 *Experientia* and *experimentum* are usually synonyms and mean 'test' or 'experience'. The meaning '(scientific) experiment' is late, as is the idea of an artificial and alterable, premeditated set-up to study a certain phenomenon. Galileo and Lavoisier are often mentioned as pioneers of the latter.

104 On which see Burkert (1959). The concept is explained by Proclus thus: ‹στοιχεῖα› μὲν οὖν ἐπονομάζονται, ὧν ἡ θεωρία διικνεῖται πρὸς τὴν τῶν ἄλλων ἐπιστήμην, καὶ ἀφ' ὧν παραγίνεται ἡμῖν τῶν ἐν αὐτοῖς ἀπόρων ἡ διάλυσις ('That by which theory attains the knowledge of other things is called "elements"; from these the solution of the difficulties in those other things reaches us'; *In primum Euclidis elementorum librum commentarii*, ed. Friedlein, p. 72).

105 Many early philosophers wrote works Περὶ φύσεως. Plato and Aristotle seem to prefer οὐσία for denoting lasting being, but Aristotle uses φύσις quite often in his biological writings to denote a quasi-personalised source of teleology. On this term, see Holwerda, *Commentatio*.

106 On *sermo* in the Middle Ages, see von Moos (2011). For Heraclitus, λόγος seems to be the most important principle of the universe; its famous career is further illustrated by the beginning of John's Gospel and the later Christian use of Λόγος for the second person of the Trinity.

107 His wording for the three meanings: τὸ τὴν αὑτοῦ διάνοιαν ἐμφανῆ ποιεῖν διὰ φωνῆς μετὰ ῥημάτων τε καὶ ὀνομάτων, τὸ ἐρωτηθέντα τί ἕκαστον δυνατὸν εἶναι τὴν ἀπόκρισιν διὰ τῶν στοιχείων ἀποδοῦναι τῷ ἐρομένῳ, τὸ ἔχειν τι σημεῖον εἰπεῖν ᾧ τῶν ἁπάντων διαφέρει τὸ ἐρωτηθέν ('To render one's thought clear by voice using verbs and nouns', 'that someone if asked about it must be able in reply to provide his questioner with an account in terms of its elements', 'to be able to tell some characteristic by which the object in question differs from everything else'; 206d, 206e, 208c).

> 'He who has adduced by correct opinion the difference from other things about something – he will have become knowledgeable (ἐπιστήμων) about what beforehand he was only opinionated about.'

§12 It has become clear that much of this semantic field goes back to Plato and Aristotle and thus to classical Attic, with some terms having survived from Ionian speculation. The chronology of these processes will be studied in more detail below (chap. 7). The Latin terminology is mostly an *interpretatio romana* of the Greek semantic web. None of the Latin terms considered here lacks a clear Greek predecessor, although some (especially *disciplina* and *ratio*) have taken on a different Roman set of meanings: thus, *ratio* could not cover the entire ground λόγος does, and *disciplina* seems to have moved from its natural 'epicentre' of μάθημα to cover much of ἐπιστήμη and become a near-synonym of *scientia*. In contrast, some Greek terms were just loaned in Latin (*historia, philosophia, methodus*).

If after these considerations we pause and ask ourselves to what degree premodern times had a concept of 'science' similar to the one we have today, it becomes evident that although there was not one clear-cut term for it before the twelfth century, several Greek and Latin terms seem to point toward such a concept emerging in classical Greece. It centres around the word ἐπιστήμη, which, however, like Latin *scientia,* continues to be used in a more general sense for any kind of 'knowledge'. In Antiquity and the Middle Ages, the terms τέχνη (*ars*) and the Latin *disciplina* are also often used where we would expect 'science'. Only from the later Middle Ages, in the wake of access to more Aristotelian works in the Latin West, does *scientia* become the standard word for what is now clearly perceived as a special human activity, 'science', in need of a unique name. Despite this slow development, it has hopefully become clear that an organic unity of something recognisably similar to our 'science' can be traced in authors through this time span – Aristotle, Archimedes, Ptolemy, or Boethius, say. From the twelfth century onward, the case is beyond doubt. Part 2 will depict this development in more detail, including key quotations from the sources.

These preliminary semantic studies will help us define a set of characteristics for scientific studies that can be applied to the entire, long, time span under scrutiny (chap. 4); after this we shall return to the question of how the key terms discussed in this chapter relate to one another over time (chap. 5).

4 What is science and how does it relate to *Denkstil*?

§1 What was seen to constitute knowledge and more narrowly certain ‘scientific’ knowledge has definitely changed over time. The panorama in part 2 of this book will present snapshots from the past 2,500 years. Especially when dealing with linguistic and semantic details, it is crucial to read the sources in order to avoid abstracted, general ‘facts’ that grow out of hypotheses being repeated in secondary and tertiary literature on the history of science. The myth, which arose from the Scientific Revolution, of a linear development of science more and more closely approximating ‘truth’ was only overturned for good in the twentieth century.[1] Fleck (2015 [1st ed., 1935]) pointed out how science depends on *Denkstile* (‘thought styles’) shared by a *Denkkollektiv* (‘thought collective’), and that truth or reality is not an immovable, fixed endpoint that can be steadily approached more and more closely, but rather that all understanding within language is like an ever-moving web depending strongly on such *Denkstile* (105). Fleck defines *Denkstil* thus (130; his emphasis):

> Wir können also Denkstil *als gerichtetes Wahrnehmen, mit entsprechendem gedanklichen und sachlichen Verarbeiten des Wahrgenommenen, definieren.*[2]

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1 Of course, some earlier scholars had similarly sceptical approaches to science before Fleck. For instance, Francisco Sanches wrote in *Quod nihil scitur* (1581: 92): *Quisque sibi scientiam construit ex imaginationibus tum alterius, tum propriis: ex his alias inferunt: et ex his iterum alias; nil in rebus perpendentes, quousque labyrinthum verborum absque aliquo fundamento veritatis produxere* (‘Everyone constructs his knowledge/science from ideas, be they someone else’s or his own, from these they infer others, from these again others; they examine none of them carefully in the things themselves, until they have produced a labyrinth of words without any foundation in truth’).

2 Fleck continues: ‘Auch ist Wahrheit nicht Konvention, *sondern im historischen Längsschnitt: denkgeschichtliches Ereignis, in momentanem Zusammenhange: stilgemäßer Denkzwang*’ (‘Also, truth is not convention, *but in a historical longitudinal section: an event in the history of thought, in a momentary context: a compulsion of thought following the* Denkstil’; 2015: 131, his emphasis). Fleck was a medical researcher, and perusing his important book makes clear that it was written in haste, occasionally it contains gross errors; for instance, Fleck (41) believed the contemporaries of Columbus who would not finance his journey did so because they believed in a flat Earth. In reality, they knew that Columbus’ estimation of the Earth’s circumference was much too small. A more serious problem is that *Denkstile* quite obviously form a continuum and it is often hard to tell how much difference is required to speak of a different *Denkstil*. The *Denkstile* of Newton and Einstein may be much closer to one another than that of Aristotle, but are they to be addressed as the same one? This conceptual difficulty should be kept in mind when this concept is used in the present book.

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> 'We can thus define thought style (*Denkstil*) *as directed perception, with corresponding mental and factual processing of what is perceived*.'

This important insight was developed further by Kuhn (1970 [1st ed., 1962]), who especially emphasised the revolutionary potential of *Denkstilumwandlungen*; *Denkstil* becomes 'paradigm' with him, *Denkstilumwandlungen* 'paradigm shift' and 'scientific revolution'.[3] Some later authors, such as Feyerabend (1975), went even further, questioning science's validity in general and producing a 'relativist' current of thought among historians of science today that – in its extreme manifestation – believes there is no way to tell 'good' from 'bad' science (e.g. a flat Earth vs a round one).[4] This was clearly not the intention of Fleck, who stands at the beginning of this development; he pointed out that such webs of scientific concepts may be more or less coherent and developed, that is, more or less adequate or 'true' in a certain sense; in the case of, say, magic they have many lacunas.[5] He worked all his life as a research physician and was certainly convinced that he was doing something meaningful within the medical *Denkkollektiv* of his time.[6] Fleck's and Kuhn's approach has been further developed by some into a

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3 Fleck had rightly seen that revolutions were only one possible outcome of new discoveries: 'Jede empirische Entdeckung kann also als Denkstilergänzung, Denkstilentwicklung oder Denkstilumwandlung aufgefasst werden' ('Every empirical discovery can thus be understood as an addition, a development, or a transformation of the *Denkstil*'; 2015: 122). *Denkstilumwandlung* is what Kuhn means by 'revolution'.

4 e.g. Wootton (2015: 510–555) argues convincingly against such an approach.

5 'So bildet sich ein allseitig zusammenhängendes Getriebe der Tatsachen, durch beständige Wechselwirkung sich im Gleichgewichte erhaltend. Dieses zusammenhängende Geflecht verleiht der "Tatsachenwelt" massive Beharrlichkeit und erweckt das Gefühl fixer Wirklichkeit, selbständiger Existenz einer Welt. Je weniger zusammenhängend das System des Wissens, desto magischer ist es, desto weniger stabil und wunderfähiger die Wirklichkeit: immer gemäß dem kollektiven Denkstil' ('Thus a web of facts interrelated on all sides is formed, maintaining its balance through constant feedback. This coherent network gives the "world of facts" solid persistence and produces the feeling of a fixed reality, of an independent existence of a world. The less coherent a system of knowledge, the more magical it is, the less stable and the more open for miracles reality is: always according to the collective *Denkstil*'; Fleck 2015: 135).

6 Indeed, Fleck writes: 'Dagegen bin ich überzeugt, daß das heutige Wissen unserer heutigen Welt näher ist, das Wissen vor hundert Jahren aber der damaligen Welt wissenschaftlicher Schöpfung näher war. [...] deshalb ist unsere Wissenschaft ausgedehnter, reicher an Einzelheiten, ist komplizierter und tiefer aufgrund der größeren Zahl innerwissenschaftlicher Zusammenhänge, aber das ist alles' ('On the other hand, I am convinced that today's knowledge is closer to our world today, but that knowledge a hundred years ago was closer to the world of scientific creation at that time. [...] this is why our science is more extended, richer in details, more complicated, and deeper because of its greater number of intra-scientific connections; but that is all'; 2011: 373). Fleck's point was to negate a final scientific truth that is being approached by science.

spiralling conception of scientific progress, one that although circular in some way due to the changing *Zeitgeist*, is also developing forward in a third dimension of *Sachkenntnis* ('factual knowledge').[7] Kullmann develops this thought for embryology: since Antiquity there have been many paradigm shifts, but the amount of detail knowledge (*Detailwissen*) has steadily grown.[8] There can be no doubt that epistemological systems (*Denkstile*) such as the one we now call 'science' change and grow over time. In Greek and Latin, this was seen above in the meanings of ἐπιστήμη and *scientia:* a distinct notion of *scientia* as 'science' (not just any 'knowledge') coalesced slowly over time. Already largely present in Aristotle, it was reanimated and introduced for good only in Latin scholasticism. But let us try to define 'science' more precisely.

It would seem that science is a hermeneutic system that needs to take into account and be consistent with (συμφωνεῖν) generally known basic facts.[9] Only in early modern times does a feedback loop take shape, leading to a kind of science that produced new, previously unknown basic facts by its technological and experimental approaches, and that started to produce them on purpose and thus accelerated its pace greatly. Science may thus be likened to interpolating a mathematical function whose value is known for ever more points, although infinitely many are still not known. But then, this is too simple a conception: the fixed, known points themselves may be shifting, and science may be able to 'debunk' what is generally perceived as 'fact' in some cases and change the emphasis on which of these facts are especially important, how they relate to one another, and which ones should be cornerstones of a given science. In other words, the relationship between such 'basic facts' and scientific theories is more complex than it might seem at first sight. In part 2 of this book, examples of both such new and 'debunked' facts will be encountered. The wider question of science's relationship to 'reality' is today discussed by widely dissenting schools and cannot be pursued in detail here. In fact, this is not necessary in the present context; it suffices here

7 e.g. Graham (2013: 258), who professes a 'Kuhnian approach minus the anti-realism'.

8 Kullmann (1998: 29–33). He continues: 'Dieser Einfluß von Tradition und Zeitgeist ist von dem linearen Fortschritt in der Sacherkenntnis, den es auch gibt, sorgfältig zu trennen' ('This influence of tradition and zeitgeist has to be carefully separated from the linear progress in factual knowledge that also exists'; 34).

9 Wootton (2015: 250–309) studies the term 'fact' and finds it to be typical for the Scientific Revolution. There is no doubt that English authors then had a special predilection for this term, but the same thing could easily be expressed before, for instance as *quae constant* or simply *res* in Latin. Besides, a society or a *Denkkollektiv* does not have to be conscious of and dispose of a name for generally accepted factual knowledge, but will (or: should in its own interest) still respect it. In Antiquity, at least in astronomy the related concept of σῴζειν τὰ φαινόμενα ('saving the phenomena (in the sky)') already existed.

to identify some common ground over the past two and a half millennia regarding the criteria a human activity needs to fulfil in order to be called scientific. For this it will be best to avoid controversial philosophical concepts such as ‘truth’ or ‘objectivity’.

Thus, we are, roughly, looking for activities that seek structures and patterns in a delimited field systematically; make use of theoretical explanations and methodology; are open to new insights; and produce a kind of feedback loop between basic known facts, observations,[10] and theoretical frameworks. The interesting question of the extent to which the human mind creates or discovers such structures cannot be followed here. Of course, it may happen that such feedback loops go astray in a scientific approach and have to be completely abandoned at some point if they have become detached from the rest of science; examples include astrology, humoral medicine, or geocentricism. These are the scientific revolutions described by Kuhn (1970), or ‘research programmes’ (Lakatos) that ran aground.[11] This latter term is certainly fitting for contemporary science, but it sounds a bit grand for Antiquity, for ‘much ancient speculation had always been and continued to be more individualistic and more opportunistic than the title research programmes would suggest or allow’ (Lloyd 1987: 170).

§2 Today, the nature of concepts in general has become much discussed and unclear. What does seem clear is that concepts are usually not strictly delineated, mutually exclusive Platonic ideas. Indeed, it is often science (at least since Aristotle) that begins by fixing the exact meaning of terms by defining them more precisely or more fittingly for the science in question. For instance, a ‘berry’ in everyday language and in botany share some characteristics but not all; a cucumber would hardly pass as a berry in the former, but it does in the latter. Whereas botany has a strict definition,[12] common language works rather with something Wittgenstein (1953: 32) called ‘family resemblance’, in this case something like ‘[a]ny small globular, or ovate juicy fruit, not having a stone’ (*OED*). The terms used are not very clearly defined (how large can it be and still qualify?); this is rather a set of characteristics that should mostly apply to something for it to be assigned to the

10 But Fleck rightly points out that observation always depends on *Denkstil*: ‘Wir wollen also das voraussetzungslose Beobachten – psychologisch ein Unding, logisch ein Spielzeug – beiseite lassen’ (‘So let us leave aside observation devoid of any presupposition – psychologically an absurdity, logically a toy’; 2015: 121).

11 Lloyd (1987: 2) summarises the debate about the very criteria of science and lists the fundamental literature in it since Kuhn.

12 *OED* (s.v.) defines ‘berry’ as a ‘many-seeded inferior pulpy fruit, the seeds of which are, when mature, scattered through the pulp; called also *bacca*’.

concept in question. So, within science one often sets out with a definition of the entity to be studied. Unfortunately, for a historical study of what science is, this approach is not feasible. Indeed, it seems that for very high-level, 'abstract' terms that emerged out of groups of coalescing lower-level concepts, it will be safer to work bottom-up from these 'defining' lower-level entities than to define the term in question right away. Similar examples might include 'art', 'religion', or 'magic'. Our approach will be to find out what qualifies and qualified as science, whether together it forms an organic and meaningful whole, and then whether we can find 'defining' lower-level criteria that were shared and are still shared. Above (chap. 3 §1), it was pointed out that semantics must be structural in kind, that concepts form groups with other concepts, from overlapping to contrasting, and that they thus form *Bedeutungsfelder*. In Latin, a single central term 'science' engulfing its *Bedeutungsfeld* as a whole crystallised only in the twelfth century, as we have shown (chap. 2 §4), although sciences clearly existed before that time. Now, can descriptive criteria be found that are wide enough to describe scientific methodology and hold good not only today but also since at least the earliest clear examples of 'science' among the Greeks[13] and then the Latins, and yet are narrow enough to remain distinctive? Through these two and a half millennia, science has to be delineated from similar activities such as mythology, philosophy, religion, magic, divination, technology, or pseudo-science. The goal will be to find a set of criteria wide enough to encompass the scientific activities of people such as, say, Aristotle, Archimedes, Galen, Albertus Magnus, Leibniz, Newton, Paul Maas, and Stephen Hawking, yet narrow enough to exclude the other activities just mentioned. It has become clear (chap. 1) that the English word 'science' – in contrast to its French, German, Russian, or Modern Greek counterparts – has strayed further from the Mediaeval Latin meaning of *scientia* and Greek ἐπιστήμη (chap. 2), and it will be better to stick to these latter senses in the present context. The list of criteria proposed below (§5) will be abstracted from historical cases and does not make a modern ahistoric, deductive, or 'ontological' claim. But first some past attempts to address this question should be reviewed.

§3 A glance at history and philosophy of science from the past few decades shows that many authors have in fact completely given up trying to define what science is; some even believe that seeking to do so is the wrong approach.[14] For example, William H. Newton-Smith states (2000: 2):

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13 Chap. 24 will return to the question of whether science should be seen as beginning in Classical Greece.

14 Thus Feyerabend (1975), who cites much further literature arguing against a common structure to all sciences. Of course, he does not mean to offer a solution to the practical problem of de-

> And what is science? Once upon a time it was fashionable to attempt neat answers to this one. The logical positivists defined science in terms of what was cognitively meaningful. Sentences other than definitions were cognitively meaningful just in case they could be verified by experience. Science is then coextensive with cognitively meaningful discourse! The discourses of ethics and aesthetics were not scientific. They were not even meaningful. And Popper declined a theory as scientific if it could be falsified. But neither of these definitions even fitted all of physics, which they took to be the paradigm science. The dominant tendency at the moment is to reject the question. Science has no essence. We have constituted our idea of science around a list of paradigm exemplars (including biology, chemistry, geology, medicine, physics, zoology) of particular disciplines.

We have the impression that this could be partly due to the fact that the history of the meaning of the English word 'science' is not usually taken into account. Moreover, it may well be that science does not have an 'essence' – indeed, it may be that no human concept has one[15] – but nonetheless, it must be possible to tell science apart from non-science by some criteria. To claim the contrary is tantamount to a complete relativism in which the Earth's flatness is just as good a theory as its roundness (which is, indeed, also only an approximation, but a much better one). Of course, there are also practical reasons that make it important to be able to tell science apart from, say, pseudo-science, such as state funding institutions, which must be able to decide whom to fund. Even in authors who do not define 'science', such as Wootton (2015: 1), it often still becomes clear what they intend; in the case of Wootton, science needed 'a substantial body of evidence and could make reliable predictions', and it also had to have 'a research programme, a community of experts' and to be 'prepared to question every long-established certainty'. Wootton sees this combination emerging for the first time between 1572 and 1704, in astronomy.[16] Some of these points will be used below to deline-

termining whether an activity can be termed 'scientific' or not. The German translation of his book as *Gegen Methodenzwang* sounds much less extreme than the English *Against Method*. Feyerabend was certainly right when he argued that it is often not at all clear at the outset what method works best for a given scientific question. In fact, much of scientific activity today consists in finding the appropriate methodology for a problem at hand.

15 Fleck already knew this: 'Worte besitzen an sich keine fixe Bedeutung, sie erhalten ihren eigensten Sinn erst in einem Zusammenhange, in einem Denkgebiete. Die Nuancierung der Wortbedeutung fühlt man nur nach einer "Einführung" heraus, möge sie nun eine historische oder didaktische sein' ('Words do not have a fixed meaning in themselves; they only acquire their very meaning in a context, in a field of thought [*Denkgebiet*]. The nuance of the meaning of a word can only be felt after an "introduction", whether historical or didactic'; 2015: 72).

16 It is clear that Wootton intends 'science' as experimental natural science (even excluding mathematics), an approach that seems too rigid. Among Anglo-Saxon writers, the rôle of the experiment is often exaggerated; classical physics is used too exclusively as *the* rôle-model science ate what can be addressed as 'science' over time; others, especially the emphasis on prediction, were not central in many sciences and still are not in some, for instance in mathematics or linguistics.

Among those modern authors who do propose an explicit definition, many use concepts that cannot be used for premodern times at all. One such example is the definition by Roger French (1994: 101–102; he follows David Lindberg), who demands that science must be objective, non-religious, and experimental: 'objective, non-religious, experimental, directed to the manipulation of nature, its manipulative nature linked to technology, universal law-like statements, often mathematical'. Although most of these defining terms ultimately go back to Latin or Greek words, their modern meaning is very far removed from 'scientific' endeavour in the times before the nineteenth century.[17] The word 'objective' has a very different meaning in the modern languages than its ancestor *obiectum* – denoting a 'topic' or 'subject-matter' in Latin – the modern meaning presupposes the modern theory of the highly metaphysical dichotomy between 'subject' and 'object'. The complete lack of the 'religious', especially of God as first principle, is likewise a very recent feature of scientific principles; in many of modern science's founders, the situation was still very different. For example, Newton based his concept of absolute space on God's omnipresence (see Burtt 1954; chap. 13 §4 below). This point was pertinently criticised by Principe (2011: 36):

> The notion that scientific study, modern or otherwise, requires an atheistic – euphemistically called 'sceptical' – viewpoint is a 20th century myth proposed by those who wish science itself to be a religion (usually with themselves as its priestly hierarchy).

Others also emphasised the technological aspect of science. Thus Crowther: 'The system of behaviour by which man acquires mastery of the environment' (1941: 1). This aspect was absent in the Middle Ages and of very limited importance in Antiquity. Indeed, it fits much better the concept 'technology', which must certainly be kept apart from 'science'. Another anthropologist, Bronislav Malinowski, follows the same thrust by claiming that the Trobriand Islanders he studied

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(at a time when physics has overcome it to a great extent). Even among the paradigmatic sciences, some are not experimental (e.g. astronomy). Wootton also draws too strong an opposition between philosophy and science; he seems to overlook that science always has a theoretical and thus philosophical component. Despite these caveats, his book is good reading and the author admits (575): 'It is no part of my argument to dispute the claim that we only have the sciences we have because Aristotle and the medieval philosophers opened up certain lines of enquiry; […].' On the Scientific Revolution, see further chap. 13 below.

17 Some authors do really draw such extreme conclusions, e.g. Cunningham & Williams (1993: 410). For them, there is no science before the 'revolutionary period' (i.e. 1760–1848).

had science because they knew how to build ocean-going canoes. Now, in Latin terminology this would be an *ars* not a *scientia;* again, in English ‘technology’ would seem to be the more fitting term.[18] Finally, experimentation becomes important only during the Scientific Revolution, equally so science’s ‘manipulative’ character. The importance of mathematics is one of the main legacies of Galileo. The necessary conclusion from French’s definition would be that before the eighteenth century, there was no science at all.[19] Such definitions – of which many more could be quoted from older literature from the nineteenth and early twentieth century – arise from another modern myth, viz. that critical thinking without dogmatic presupposition was the invention of the age of ‘enlightenment’. Rather it would seem that any kind of thinking is always dependent on its cultural background (or *Denkstil*) and makes use of it more or less unconsciously. Later epochs will discard or replace parts of this background with something else and then wonder how their predecessors could have been blind to its ‘obvious’ misguidedness.[20] The same will happen to our own present-day prejudices and misconceptions to which we are more or less blind. For historical or comparative research, such a modern definition is therefore clearly of no use and we must try to find one that is both broader and in its defining characteristics less dependent on unconscious contemporary philosophical concepts. Altmann (1993: 3, following Mario Bunge) uses a very mathematical approach when he defines:

Science = <Object, Approach, Theory>[21]

However, this does not seem to suffice either: although it may be that all science can be described in such a way, other things can be as well. For instance, the invocation of demons may be: <demons, magic spells authorised by tradition, classical demonology>. Besides, such a mathematical definition does not do justice to the way science actually works, develops, and is taught.

18 Compare Malinowski (1925: 35), discussed by Tambiah (1990: 67–68).

19 This conclusion is actually drawn by some authors, such as Wootton (see n16 above).

20 ‘Die Prinzipien eines fremden Kollektivs empfindet man – wenn man sie überhaupt bemerkt – als willkürlich, ihre eventuelle Legitimierung als petitio principii. Der fremde Gedankenstil mutet als Mystik an, die von ihm verworfenen Fragen werden oft als eben die wichtigsten betrachtet’ (‘The principles of an alien collective – if one notices them at all – are perceived as arbitrary, their possible legitimation as a *petitio principii*. The foreign style of thought [*Gedankenstil*] appears to be mysticism, the questions it rejects are often considered the most important ones’; Fleck 2015: 143).

21 Mathematically, this means that the ‘science’ is a function of the three concepts in the angled brackets.

One example of a definition that owes less to fashionable philosophical terms but is still meant to describe twentieth-century science (especially physics) is that proposed by an actual natural scientist, Richard Feynman (in Leighton 1964: 1). He presents it as the search for patterns (a word that comes close to one of the meanings of Greek λόγοι), in which the goal of science is reached through experimentation:

> The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth'. But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations – to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess.

The emphasis on experimentation is still very modern, but the quest for underlying patterns seems promising. Others, especially authors concerned with the history of science beyond the past few hundred years, inevitably propose wider definitions. George Sarton defined his object of study in a very wide manner as 'systematized positive knowledge'.[22] This definition, again, may be too wide, as it will, for instance, include rules for magic practices (which Sarton, of course, does not treat in his monumental work). In the following pages, Sarton makes clearer what he means by this succinct definition: he rightly does indeed include fields such as philology and historiography in his work – quite against English usage even then, but agreeing with the 'international' one.[23] Van der Waerden uses a similar approach when he sees *Wissenschaft* as 'systematisch geordnetes Wissen' ('systematically ordered knowledge') in general.[24] These authors might argue that the magician has no real knowledge and therefore does not practise science. But how do they tell real knowledge apart from imagined knowledge (δόξα)? Indeed, the present endeavour is largely that of finding a means to tell mere δόξα apart from science (or philosophy), which is still the same task Plato grappled with. Plato ended up with the construction of a realm of eternal truths (his 'ideas') which we can attain in philosophy and mathematics. This ideal was to be very persis-

22 Sarton (1927–1948: 1:3–4). It may be noted in passing that defining science using the word 'knowledge' is not an option in Latin, as both these concepts are expressed by the one word *scientia*.

23 Sarton (1927–1948: 1:7) points out: 'I have attached much importance to the study of philology. The discovery of the logical structure of language was as much a scientific discovery as, for example, the discovery of the anatomical structure of the body.'

24 Van der Waerden (1966: 9); this volume was originally published in German.

tent, but it is very hard today to share in its strict sense (although some would claim that mathematics constitutes this eternal ideal realm).[25] Above (chap. 3), it was shown that for Greek and Latin authors, a foundation of certain and timeless explanatory reasoned force was central in differentiating ἐπιστήμη/*scientia* from mere opinion. Insights in the twentieth century in many fields, however, have made full certainty rather illusory (even in the paradigmatic a priori science of mathematics); but the greatest possible, often statistical, certainty would still seem to be part of science's goals. So, although we have had to become more modest, the basic drive for certainty is still central to science.[26]

§4 A matter that certainly complicates a definition of science is the rift between natural and human sciences that has become increasingly palpable over the past century.[27] Above (chap. 2), it became clear that this problem is especially acute in English, a language that would no longer call *Geisteswissenschaftler* scientists. But as means of acquiring reasonably certain and testable knowledge outside the realm of 'nature' do not seem to be categorically different from the natural sciences – which, by the way, differ a lot among themselves – it would not seem wise to exclude all non-natural or non-exact sciences from science. Several traditionally 'humanist' fields (such as linguistics, computational linguistics, archaeology) are mingling more and more with the natural sciences in the twenty-first century.[28] Indeed, they all seek patterns, symmetries, or other in some way invariant structures.[29] As sciences progress, they tend to move from description to ever deeper explanatory patterns 'behind' the observational data, as Feynman pointed out. A good example is Galois theory.[30] This field, inaugurated by the genius Évar-

25 Such as Penrose (2004: §34.6).
26 See Gambino Longo (2015) on certainty in science.
27 The paradigmatic text for this is Snow (1963). See now Leavis (2013). Staal (1996: chap. 29) tries to refute the 'myth of the two cultures'.
28 Mainzer followed similar lines of thought and found a 'unity of methods': 'Allerdings ist diese neue Einheit von Methoden in Mathematik, Kunst und Naturwissenschaft von grundsätzlich anderen Absichten getragen, als im pythagoräischen Quadrivium. Es kann nicht mehr darum gehen, Tonskalen und Harmonien als Ausdruck bestimmter Naturgesetze zu verstehen. Philosophisch gesprochen handelt es sich also heute um eine Einheit der Methoden und keine ontologisch begründete Einheit wie bei den Pythagoräern' ('However, this new unity of methods in mathematics, art, and natural science is based on fundamentally different intentions than in the Pythagorean *quadrivium*. The point can no longer be to understand tonal scales and harmonies as an expression of some laws of nature. Philosophically speaking, then, we are dealing today with a unity of methods and not with an ontologically based unity as with the Pythagoreans'; 1988: 180).
29 Showing this is one of the main goals of Mainzer (1988).
30 See Mainzer (1988: 185–196). A good introduction to Galois theory is Artin (1944).

iste Galois (1811–1832), who tragically died in a duel, approached both traditional geometry and the problem of solving polynomial equations with root expressions from a deeper structural level (viz. group theory), and was thus able to offer solutions for centuries-old problems: in constructive geometry, Galois theory proves the impossibility of the trisection of angles, and in the field of polynomial equations, it proves that the solutions of equations of the fifth degree and higher are, in general, not root expressions.

Of course, the more 'abstract' and deeper our scientific structures get, the greater the danger that they may not reflect inherent characteristics but accidental ones. This can be seen historically in astrology or humoral theory in Antiquity and the Middle Ages: these very abstract superstructures far removed from observable facts were so complex that it was hardly possible to falsify them – until a new paradigm removed their very foundations and they finally lost credence. This makes 'testability' in some form crucial in order not to get stuck in what has been aptly termed a 'null field'.[31]

§5 The rôle of language within science is often underestimated: in what follows, a tentative list of criteria (including linguistic ones) will be proposed that an activity should fulfil in order to be called scientific. This is more circumscribing the phenomena that have passed as scientific over the millennia than actually defining them, which may well be better avoided.[32] In line with Wittgenstein's 'family resemblance', it will not be advisable to demand that all criteria be completely fulfilled for an activity to be termed 'science' – even contemporary model sciences may fail to meet some of them. Rather, it will be sufficient if they are fulfilled mostly and in general. First, non-linguistic criteria for scientific activities abstracted from the above discussion are proposed. As will become clear below, point (IV) has the consequence that some disciplines or activities may at one time have been scientific but are no longer so (e.g. astrology). In short, the proposed criteria for a *Denkstil* to pass as scientific are

(I) a systematic methodology and well-defined topic,
(II) finding patterns and explaining them step-by-step,
(III) unbiased seeking of confirmation or refutation.

31 This term is used by Ioannidis (2005) to denote 'fields with absolutely no yield of true scientific information, at least based on our current understanding'. He points out that in such fields, the positive results one gets correspond only to bias. It is often not a trivial matter to see that a field is a null field, as the long-persisting examples mentioned show.

32 After all, definitions are used *within* scientific activities.

The following criteria may be added, but they seem less central:

(IV) coherence and non-sterility,
(V) community effort,
(VI) formalisation of results.

The final point (VI) is linked to the criteria scientific language should fulfil. But before dealing with such linguistic criteria, those in the above list need some clarifications, including relevant Greek and Latin concepts from science's past.

(I) A systematic method for solving certain kinds of questions (a μέθοδος, *methodus sciendi*).[33] Heuristically, scientific knowledge is gained by a procedure or method[34] that is in some way reproducible: one that can be followed again by others, leading to comparable results. It should at least in part be possible to retrieve new insights systematically from those already possessed. The importance of the term 'system' can be traced back to the Scientific Revolution.[35] In the present context, 'systematic' is only meant to imply that knowledge is not collected haphazardly. This is often stressed as fundamental, for instance in the quotation from Störig in §6 below. According to von Weizsäcker (1991: 176), *Wissenschaft* can be boiled down to 'planmäßiges Fragen' ('the methodical asking of questions'). Kuhn already saw 'normal science as problem solving'.[36] What method is to be used may be highly controversial, and may lead to Kuhnian paradigm shifts. From this it follows that every science, during 'normal' (non-revolutionary) development, tends to become demarcated in its own clearly defined topic (Aristotle's ὑποκείμενον), which determines to some extent the methods best used in its exploration. Thus, these cannot be independent of the topic under scrutiny,[37] leading to a dialectic process between the two. As Putnam puts it: 'It is not possible to draw a sharp line between the content of science and the method of science; [...] the method of science changes as the content of science changes' (1981: 191).

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33 This 'scientific method' is mentioned by Sanches, *Quod nihil scitur* (1581), p. 100, where he resolves to write a book about it (which he never did). On his scepticism, see Caluori (2007).

34 μέθοδος, literally a 'path after something'; see chap. 3 §9 above.

35 See Ritschl (1906). Before that, the Greek and Latin term was used in many circumstances but not in epistemology. Forcellini writes: *compages, constructio. Solet in scientiarum studiis adhiberi pro ingeniose excogitata rerum dispositione, quo sensu tamen deest nobis Latini scriptoris exemplum* ('a joint structure, a joining together. It is employed in the studies of the sciences for an ingeniously contrived disposition of things, for which sense, however, we lack an example from an [antique] Latin writer'; s.v. *systema*).

36 Kuhn (1970: chap. 4 title). Kuhn's novel approach consisted in identifying, beside this slowly progressing development in science, the revolutionary, paradigm-shifting one.

37 Lakatos (1978) speaks of 'scientific research programmes'. Tambiah (1990: 68) characterises science as a 'self-conscious, reflexive, open-ended process of knowledge construction'.

(II) Spotting regularities, patterns, in something and trying to understand why they are the way they are, then explaining them step-by-step, is the second crucial point. This may be linked to the traditional attributes of scientific knowledge as σαφές, *manifestum, certum*. Science means to find out step-by-step *how* something came about or happens, and is not content with the knowledge *that* it happens or its ultimate cause. But what counts as an explanation of something? For instance, aetiological myths also offer explanations. As Lloyd (1987: 287) points out:

> The emergence of what can begin to be called fully fledged explanations of classes of natural phenomena is an important new development, though a hesitant one, in early Greek philosophy, with the practice of such explanations preceding the theory.

What exactly qualifies as a sufficient explanation depends a lot on time and scientific culture (*Denkstil*), but the important point is that science aims at the understanding of mechanisms. Different kinds of mechanisms may be allowed to be explanatory; during the heyday of the mechanical universe, for instance, only mechanical explanations – i.e. ones that entail actions through contact between pieces of matter – were accepted. In other times, the mere finding of a source quotation in an authoritative text will have sufficed as an explanation. Thus, a more precise narrowing down may be inadvisable, but mechanisms are further restricted by criteria III and IV.

(III) The criterion of the unbiased search for confirmation or refutation, that is, some general form of testability (ἐμπειρία, *experimentum*) is somewhat wider than the often-quoted 'empiricity'. Scientific activity must be based on some kind of experience or observation (in a wide sense) shared by most human beings, possibly instructed beforehand.[38] Thus, it needs to be in concord with empiricity (ἐμπειρία); in Antiquity this is called συμφωνεῖν, its contrary ἀντιμαρτυρεῖν. Scientific constructs ('theories') should produce predictions that can be tested in some way proper to the topic. Besides, basic, generally acknowledged facts must not be contradicted, unless they can be debunked in a methodologically sound way. Thus, systematic doubt becomes the methodological foundation. As the old proverb has it: *Qui nihil scit, nihil dubitat* ('He who knows nothing, doubts nothing').[39] Modern definitions in the wake of Popper often narrow this criterion to

38 This may be what is intended by 'objective', but because of its history of dramatically changing meanings, it will be better to avoid this word. 'Most human beings': often the insane are excluded. 'Instructed beforehand': they may have to learn to read before they can, say, check a quotation, or to count before they can count events. So, they have to be initiated into a Fleckian *Denkstil*.

39 Mentioned in Ps-Bede, *Sententiae philosophicae collectae ex Aristotele atque Cicerone* PL 90.990C. Not in Jones (1939), Otto (1962), or Walther (1963–1986).

'falsifiability'. For a historically applicable approach, it will be better to be content with a wide 'minimal' empiricism,[40] in which any kind of testing an outcome, including non-physical ones, is acceptable. Examples would be mathematics, where theorems can be 'checked' or 'tested' (by proof) although they are not usually upheld by attempts at empirical falsification, or mediaeval scholastic theology, whose conclusions drawn from harmonising authorities could be 'checked' in the authoritative source texts.[41] To put it differently: the scientist should lack credulity but be of a curious nature.[42] This curiosity is the famous θαυμάζειν that lies at the root of philosophy according to Aristotle (*Metaphysica* A2, 982b12–13):

> διὰ γὰρ τὸ θαυμάζειν οἱ ἄνθρωποι καὶ νῦν καὶ τὸ πρῶτον ἤρξαντο φιλοσοφεῖν.
> 'Men begin today and began first to philosophise through marvelling.'

The very contrary of testability is authoritarianism. Already in Antiquity, the Pythagoreans used to finish arguments with an authoritarian αὐτὸς ἔφα ('He said it').[43] Pseudo-science is still often characterised today by blindly following what someone has proclaimed to be the truth.[44]

As a subcategory one can mention impartiality, or the lack of bias. Often a scientist sets out to prove something but through 'testing' ends up with a completely different result. Thus, no undue priority should be given to one's favoured points of view in science. These may be based on prejudices such as nationalism or personal preference for one theory over its competitors. Max Weber called this *Wertfreiheit* ('the lack of value-statements').[45] Of course, this criterion is always difficult to attain, as it seems to be part of the human mind to cling to its previous knowledge and to become biased. It has been objected that science needs value statements of the kind 'correct' (e.g. 2 + 2 = 4) and 'wrong' (e.g. 2 + 2 = 3). Thus, 'lack of bias' may be a better term than *Wertfreiheit;* similarly, von Fritz (1971: 317) would only demand the absence of ideological propaganda. A step in this direction within scholasticism may be seen in the attempt to prove the existence of

40 See Schurz (2008: 14).
41 Modern people may object that such a scholastic 'set of axioms' made up of Holy Scripture is far from free of contradictions. But scholasticism grew out of the problem of having to deal with such – for its exponents – only apparent contradictions. See more on this topic below (chap. 11).
42 Augustine seems to agree with this (Tasinato 1994), but his personal conclusion was, nevertheless, to largely abandon worldly science in favour of Christianity in his later life (see chap. 9 §2 below).
43 e.g. in Diogenes Laertius, *De vita philosophorum* VIII.46, ed. Long, vol. 2, p. 414.
44 As examples today, un-scientific Marxists or Freudians may be mentioned.
45 Weber (1917/1918); he dealt with the social sciences.

God instead of merely taking it as revealed truth.[46] The claim of God's existence was, however, not seriously challenged, and the Christian dogmatic truths remained universally accepted 'axioms' among Christian writers until far into modern times.

Criteria (II) and (III) are the fundamental ones: by unbiased observation, then capturing patterns with theories, then renewed unbiased observing and testing, science can and does begin to 'walk' on these 'two legs', as Galen puts it.[47] As it 'walks' on, ever greater rigour is necessary to counter fallacies that are uncovered and to render methodology more adequate to the topic in question.

The three final criteria may be seen as optional: some sciences were not yet coherent with the other accepted sciences of their times, in some times and places there were not enough scientifically minded people for much of a community effort, and some sciences have largely withstood formalisation to this day.

(IV) Coherence and non-sterility: results and theories within a science and between sciences should be coherent and should meaningfully fit together in order to lead to wider theories, and not just end up as a patchwork of unrelated facts. A scientific approach should also have the potential for further heuristic development,[48] often ending up explaining phenomena that were in the beginning not even intended to be covered (which is what we intend with the term 'non-sterility' or 'fruitfulness'). An extreme 'theory' that does not meet this criterion could be 'God made everything the way He liked'. This 'explains' everything but is not at all fruitful for the generation of further knowledge and cannot be considered scientific.[49] A scientific theory should be open to modification by new insights. From

46 Anselm of Canterbury started this with his famous ontological proof of God's existence. Some two centuries later, Raimundus Lullus extended the idea and tried to prove the main Christian dogmas in order to be able to convert scientifically minded non-Christians. He was generally seen as having gone too far with this, possibly also because it rather failed to produce any result remotely convincing to non-Christians.

47 Galen described with this simile his understanding of scientific medicine: *De compositione medicamentorum secundum locos libri X*: εἰς τὸ βαδίζειν ἑκάτερον τῶν σκελῶν εἰσφέρεται, τοιαύτην ‹δύναμιν› ἐν ἰατρικῇ τὴν ἐμπειρίαν τε καὶ τὸν λόγον ἔχειν ('In order to walk, both legs contribute; in medicine experience and reason possess this force'; XIII.188, ed. Kühn, vol. 13, p. 188). A conciser form, ἔστι γὰρ ἐν τῇ ἰατρικῇ ὡς δύο σκέλη, ἐμπειρία τε καὶ λόγος ('for there are as if two legs in medicine: experience and reason'; XVI.81, vol. 13, p. 188), comes from a Renaissance forgery (see Garofalo 2005: 445–447).

48 Gruenberger (1962: 3): 'fruitfulness is one of the attributes of science'. Mainzer rightly points out that the 'heuristische Möglichkeiten eines Wissenschaftsprogramms' ('heuristic capabilities of a research programme'; 1988: 68) are more important than falsification of some peripheral consequence.

49 See below (chap. 7 §4) for Plato's fruitful, albeit rather un-scientific approach to astronomy.

scientific openness follows a theory's ability to be further developed and a lack of dogmatic rigidity.

A certain coherence (*unitas scientiarum*)[50] with what is known from other scientific branches may be required so as to have a science fit into the accepted scientific *Denkstil*. In the extreme case, all sciences will form one hierarchically structured single body of non-contradictory, coherent knowledge. This is an idea that stood at the basis of the antique circle of education, the ἐγκύκλιος παιδεία (see chap. 9). Even before that, Aristotelianism emphasised an interconnected 'network of the sciences'.[51] In early modern times, Descartes stressed this point as well.[52] Clearly, taken strictly, this criterion narrows down what can pass as science considerably. For instance, astrology was usually considered a reputable science that fitted well into the Aristotelian *Weltbild* claiming that the relative positions of the planets affected the centre of the universe (the Earth), until the advent of heliocentricism and until new ways of understanding forces gained ground in the Scientific Revolution. This left astrology completely out of touch with the other sciences, and thus it came into disrepute as a science and is today considered a pseudo-science.[53]

This criterion thus unites all sciences to some degree into a whole. The demarcating lines between various sciences may often be disputed, but at least some coherence among them should be expected: after all, we live in one unified whole (the 'universe'). On the other hand, this coherence also leads to 'paradigms' (as shown by Kuhn) that may become too rigid and in need of being broken apart in order to allow further progress in understanding. Edward Wilson (1998) called this criterion 'consilience'. The idea of the coherence of scientific theories and fields is also related to Lakatos's 'research programmes': scientific facts have to come in groups, not as small insights or facts. On the other hand, the

50 This phrase is already common in Spanish neo-scholasticism, for example in Francisco Suárez, *Disputationes metaphysicae* XLIV.11.55, ed. Berton, vol. 26, p. 711.

51 On which in the thirteenth century, see Fidora (2011).

52 Cf. Descartes, *Regulae,* ed. Wohlers, p. 4: *Credendumque est, ita omnes* [*scientiae*] *inter se esse connexas, ut longe facilius sit cunctas simul addiscere, quam unicam ab aliis separare* ('It is to be believed that all sciences are thus connected among one another such that it is much easier to learn all of them together than to separate a single one from the others').

53 On the details of this long process, see Lerch (2015). Strangely enough, Thorndike (1923–1958) is not aware of this and treats astrology as a pseudo-science already in Antiquity. This makes his outlook on scientifically minded people in Antiquity very thin, as even men such as Ptolemy and Galen failed to 'notice' astrology's fallacy. Our argumentation is shared by Kuhn (1970: 2): 'If, on the other hand, they [out-of-date beliefs] are to be called science, then science has included bodies of belief quite incompatible with the ones we hold today. Given these alternatives, the historian must choose the latter.'

greater the number of such uncontroversial facts in a scientific field, the less freedom (so to speak) it has and the more realistic the scientific approach is likely to become. This way, many theories become ruled out by facts that have become common knowledge. This can be observed well among the 'pre-Socratics'; for instance, the sphericity of the Earth becomes common knowledge in the fourth century BC in Greece, ruling out all other older, often fanciful theories of its shape.[54]

(V) Community effort. A community of scientists that is as large as possible and able and willing to share its results is clearly also of great importance: there is much too much to study for a single human life. Aristotle is the first known scientist who worked with a team, as we shall see below (chap. 7 §6). Albertus Magnus was also well aware of this scientific *societas*.[55] The scientific community's knowledge is likely to grow with time.[56] For this to work well, external factors seem necessary: the possibility of fixing knowledge permanently, as in writing; some political stability to allow interchange; some but not too much competition between scientists, who might otherwise be reluctant to share their insights or fake results. Besides, they need to be able to understand one another: a mutually intelligible scientific language comes into play here, which in turn will have criteria of its own (to be discussed below). This community effort requires teachability: insight and methodology must be communicable and must be teachable and learnable, as Aristotle, quoted above (chap. 3 §4), already pointed out. The crucial rôle of the *Gemeinschaft* in shaping a scientific *Denkstil* is also pointed out by Fleck (2011: 470).

(VI) Formalisation of the results. The insight gained by a science should lend itself to description in a formal, rigorous way, which may make use of special symbols, diagrams, or a special type of language.[57] We have seen above that the μαθήματα from classical Greek times onward had a tendency to become more and more formalised (chap. 3 §3), reaching a first peak, for instance, in Euclid's *Elementa*. The frequently invoked necessity of *rationalitas* in science can also be seen

54 Described by Graham (2013); see also Gleede (2021: 2–10, and other sections treating later, mostly Syrian Christian, authors who did not accept the Greek consensus).

55 e.g. Albertus Magnus, *Politica*, ed. Borgnet, vol. 4, p. 500: *in omni autem corpore humor fellum est, qui euaporando totum amaricat corpus, ita in studio semper sunt quidam amarissimi et fellei uiri, qui omnes alios conuertunt in amaritudinem, nec sinunt eos in dulcedine societatis quaerere ueritatem* ('but in every body there is bilious humour which when evaporating renders the entire body bitter, similarly in science there are always some very bitter and bilious men who turn everyone else into bitterness and do not let them seek truth in the sweetness of companionship').

56 Despite the now generally acknowledged fact of upheavals or revolutions in the history of science and their important rôle in its progress (see Kuhn 1970 [1st ed., 1962], and the vast literature his work sparked), there is still an overall progress to be observed, as pointed out above.

57 Further on this topic, see chap. 14 §7 below.

in the light of formalisation, in this case of a logical kind. In early modern times, Galileo is so convinced of the importance of formal languages that he claims that mathematics (the most rigorous type of formalisation known) is God's language (see chap. 13 §§3–4). But clearly, not all sciences can produce their knowledge in mathematical form; indeed, even in mathematics itself human language is needed to explain at least what the symbols stand for. Thus, the need for a specific language of science that can neither be pure mathematics nor everyday language becomes obvious. This thought is pursued further in §7.

§6 Before this, first a few authors who have used similar approaches to 'define' science will be considered. This problem is tackled by Graham for similar and very practical reasons (he studies the emergence of Greek astronomy). The results in his appendix 2 are similar to our proposed wider set of criteria; he concludes with a definition, called S, of (natural) science as (Graham 2013: 256):

> S. Science is a) a systematic study of the natural world, b) using accepted theory and methodology, c) allowing for open inquiry within (b), d) permitting elaboration and revision of (b), e) based on empirical evidence.

Typically for the narrower modern English meaning of 'science', the activities are restricted to nature in (a). Without this restriction, less formally but in some more detail, Störig (1965: 13–16) describes science thus:

> Wissenschaftliches Wissen ist gewonnen durch planmäßiges, methodisches Forschen, und es ist systematisch in einem Zusammenhang geordnet. […]
> Wissenschaft als Inbegriff solchen Erkennens und seiner Ergebnisse können wir nunmehr vorläufig definieren: einerseits als Prozeß methodischer Forschung und zielbewusster Erkenntnisarbeit aus ursprünglichem sachlichen Wissenwollen und Fragen nach der Wahrheit; andererseits als Schatz methodisch gewonnener und systematisch geordneter Erkenntnisse, die mit dem Anspruch auf allgemeine Gültigkeit und zwingenden Charakter auftreten.
> 'Scientific knowledge is gained by systematic and methodological inquiry, and it is ordered systematically into context. […]
> We can now provisionally define science as the embodiment of such knowledge and its results: on the one hand as a process of methodological enquiry and progressive knowledge aware of its aim, born out of an initial wish to know the facts and an enquiry into truth, on the other hand as a stockpile of knowledge gained methodologically and ordered systematically which claims for itself general validity and a necessary character.'

It may be noted here in passing that the German language can use compounds and expressions that are quite untranslatable into English or Latin. For instance, the phrases *zielbewusste Erkenntnisarbeit* and *ursprüngliches sachliches Wissenwollen* are clear to any educated speaker of German (even though the compound *Erkenntnisarbeit* does not figure in any dictionary), but in order to translate them into English or Latin one must use long circumlocutions; we see here a typically German scientific *Denkstil* at work (see further chap. 24).[58]

Similarly, Vlastos (1975: 36) proposed three criteria, roughly corresponding to our II and III:

> By 'scientifically ascertained facts' I understand facts satisfying three basic requirements:
> (i) They are established by observation or by inference from it: they are derived, directly or indirectly, by the use of the senses;
> (ii) They have theoretical significance: they provide answers to questions posed by theory;
> (iii) They are shareable and corrigible: they are the common property of qualified investigators who are aware of possible sources of observational error and are in a position to repeat or vary the observation to eliminate or reduce suspected error.

Staal (1996: 351–352) also proposed a descriptive list similar to ours. It is intentionally rather vague and to some extent repetitive. It can be condensed to (i) a body of statements, rules, and so on that can be tested; (ii) abstract statements that go beyond that data; (iii) consistency of the edifice built out of (i) and (ii); and (iv) the existence of some methodology of argumentation. Some sociologists, such as Robert K. Merton (1973: 270), demand ethical 'imperatives' for science that roughly correspond to our points (II) and (V): 'universalism, communism, disinterestedness, organized skepticism'.

The authors quoted in this section seem to agree with our approach that although science should not be defined outright, it can still be described reasonably well with a set of criteria. Thus, we agree with Staal that the exact list of criteria does not matter too much, as long as it covers the essential points that have been mentioned. But it seems that the language science uses should be more emphatically treated than in the proposals considered (hinted at in Staal's (iv)). Indeed, the importance of the precise and critical use of language for science will become evident when studying many of the so-called pre-Socratic philosophers, who by and large lacked it and should therefore, it would seem, not be called scientists (see chap. 7). Occasionally, this point was stressed in the past, for example by the physicist Léon Brillouin (1959: ix):

> Science begins when the meaning of the words is strictly delimited. Words may be selected from the existing vocabulary or new words may be coined, but they all are given a new definition, which prevents misunderstandings and ambiguities within the chapter of science where they are used.

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58 There is a lexicon of such untranslatable, especially philosophical vocabulary: Cassin (2004), which however (somewhat disappointingly) treats almost exclusively specialised philosophical terminology.

The first three points in our proposed list are the most central ones; they resemble strongly the way Aristotle did scientific research. Indeed, science may be seen as a further development of the Peripatetic *Denkstil*,[59] although the results of Peripatetic science are nearly all rejected today and the methodologies in the various fields have also often changed radically. Aristotle laid the foundations of logic in his *Organon*, and started many empirical sciences more or less from scratch (such as zoology or the study of city constitutions). His school, the Peripatos, continued along these same lines. This will be considered further below (chap. 7 §5).

§7 The above criteria already suggest certain features of the language used to communicate what scientific research has found. These will pertain on the one hand to technical terminology, but also to syntax and in general the logic of linking thoughts. Like science itself, its language should be systematic and explain matters clearly; it should be coherent and mutually understandable by as many scientists working in similar research fields as possible. It has already been pointed out that such language criteria may be seen as by-products of a tendency in science to formalise insight (criterion VI). This leads to criteria such as the following ones (which are not exhaustive):

(i) well-defined terminology,
(ii) exactness and unambiguity,
(iii) extendability and flexibility,
(iv) perspicuity,
(v) evidentiality and modality.

Latin quotations from authors in part 2 will show the importance of these criteria to what 'scientists' did and how they expressed it. First, though, some more details about these criteria are required.

(i) Well-defined and standardised terminology. Communication between scientists is seriously hampered if the scientific vocabulary is not clearly defined and free from contradictions in its terms. On the one hand, this just means that the same word should be used when speaking about the same phenomenon. This criterion was often, for instance, not met by mediaeval alchemists, who used terms such as *sulfur* very differently from one another; or, in Latin medicine, Celsus[60] criticised a lack of common terminology for tumours of the

59 The significant difference between Aristotle's own practical work and his theoretical basis in the *Analytica* is considered below (chap. 7 §5).
60 *De medicina* VII.6.1, ed. Marx, p. 311.

head.[61] On the other hand and more broadly, terminology and syntactic uses are often automatically understandable to speakers of a language and should not be used counter-intuitively. Thus, 'life sciences' study living organisms; it would be inappropriate to use this designation for, say, geology. Nonetheless, by historical accident such inaptly named terms may be coined and may even survive; for instance, we know today that despite its name, 'oxygen' has nothing to do with acids. As knowledge of Greek and Latin is more and more disappearing among scientists today, new terminology is sometimes erroneously formed from these languages. Some examples of this will be discussed below (chap. 21 §5).

(ii) Exactness (*exactum*, τὸ ἀκριβές) is a general feature of scientific study. Kurz (1970) followed its growing importance among Hippocratic doctors and sophists to Thucydides, Plato, and Aristotle. The word ἀκριβής seems to have been used first to designate a quality in crafts (τέχναι) as 'nicht allgemein verbreiteter Sachverstand' ('not generally available expertise'; Kurz 1970: 11). For Plato, as for many later scientists, the greatest exactness is found in mathematical methods (105). Scientific terminology should also as far as possible be unambiguous (*univocum*, ἀναμφίβολον) in order not to reach conclusions about something by using a particular word in different meanings. This point is stressed emphatically by Aristotle when he finds that a term πολλαχῶς λέγεται.[62] Indeed, he proposes an entire theory of the metaphorical versus literal meaning of terms.[63] For instance, Aristotle points out that Plato's forms are mere poetic metaphors,[64] but he himself also uses potentially ambiguous terms, such as ὕλη or εἶδος, although the wide range of meanings that these terms cover for us may have represented a single concept for him (see Lloyd 1987: 175). This suggests that the unambiguity of terms is not a trivial concept in itself: although some words clearly have several clear-cut and non-overlapping meanings (e.g. 'ear' of an animal vs 'ear' of corn), often going back to different etymons (compare German *Ohr* vs *Ähre*), this is often not the case, yet their meaning can be very wide. We have seen, for instance, that the Greek term λόγος (introduction, §2) has to be translated by several words into Latin or English, depending on context. Aristotle's criticism caught on, and analysing technical terminologies, keeping them as far as possible free from metaphor, became common in many fields, but it also became

61 More examples of synonymous medical terminology in Antiquity are collected by Fögen (2009: 42–43).

62 e.g. Aristotle, *Topica* I.18, 108a31–32: Τοῦτο δ' οὐκ ἐπὶ πάντων δυνατόν, ἀλλ' ὅταν ᾖ τῶν πολλαχῶς λεγομένων τὰ μὲν ἀληθῆ τὰ δὲ ψευδῆ ('This, however, is not possible in all cases but only when some of the various meanings are true and others false').

63 Studied by Lloyd (1987: chap. 4).

64 *Metaphysica* A9, 991a.

a rhetorical weapon against one's opponents.[65] Quintilian rightly stresses that syntactic *ambiguitas* is also to be avoided.[66]

(iii) Extendability and flexibility: a language of science must be able to express newly discovered facts. Thus, a certain flexibility and clear rules for producing new words or syntagms for new content are required. In some languages, such as Greek or German, new terminology that is at once understandable to the audience can be introduced tacitly. In Latin this is usually done explicitly, for instance by adding *quod x vocatur/vocamus/vocari potest*. In chapters 21 and 24, it will be seen that in Latin the main linguistic tool for forming new terms was suffixation, while Greek more often uses compounding and nominalisation with the article. Classically minded Latin humanists usually avoided the coining of new words altogether and had to resort to syntagms, often nouns modified by adjectives, to express new concepts, such as *bilis atra* (see further chap. 21 §3). It has already been pointed out that German is in this respect closer to Greek (using grammatical features) and English closer to Latin (both are of a rather more analytical nature and tend to shun new words).

(iv) Perspicuity or clarity: scientific language should be easily and unambiguously understood by experts in a field. Ancient rhetoric often stresses the importance of *perspicuitas*, in Greek σαφήνεια, and that its opposite *obscuritas* should be shunned.[67] Quintilian[68] points out that regional, archaic, or obscure terminology should be avoided. Other terms often used in Latin for this aim in scientific texts are that they should be written *articulatim*, *distincte*, and *dilucide* ('appropriately structured', 'distinctly', 'clearly'). Again, this holds true not only for vocabulary but also for syntax. Concision (*brevitas*, συντονία)[69] is also often mentioned as a means for perspicuity, although, of course, exaggerated concision would lead to *obscuritas*. This implies that scientific language avoids not only inconsistencies but also redundancy. Scholastic authors such as Thomas Aquinas follow this rhetorical[70] approach; he sums it up as (*Summa theologiae* proem., Leonina edition, vol. 4, p. 5):

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65 'Aristotle's invention of the metaphorical/literal dichotomy involved the stipulation of criteria for truth that at one stroke downgraded – even ruled out – poetry, most traditional wisdom, and even much of earlier philosophy' (Lloyd 1987: 210).

66 *Institutio oratoria* VIII.2.14, ed. Rahn, vol. 2, p. 144. He does this in general, not specifically for *Fachsprache*. His examples are from Vergil.

67 More details in Fögen (2009: 28–29).

68 *Institutio oratoria,* esp. VIII.2, ed. Rahn, pp. 139–149.

69 Fögen (2009: 30).

70 Already stressed in the earliest Latin text on rhetoric we have, *Ad Herennium* I.27, ed. Achard, p. 28: *Sedulo dedimus operam, ut breviter et dilucide, quibus de rebus adhuc dicendum fuit, diceremus* ('We endeavoured diligently to speak briefly and clearly about the remaining topics').

> *breviter ac dilucide prosequi, secundum quod materia patietur.*
> 'proceed with brevity and clarity, as far as the matter allows.'

(v) Evidentiality and modality: where does the evidence for an assertion come from?[71] Are modes of statements, such as reality, conditionality, potentiality, or counter-factuality, distinguished in a clear way? Both these related points are important for scientific language; usually, particles and/or verbal tenses are used in this function. Greek, Latin, and English use both these devices. Logical nexuses in science are often expressed by conditional clauses. If-clauses are especially developed in the Indo-European languages of science considered above (chap. 1); they all have tense rules applying exclusively to them (e.g. not allowing '*if I would do …'). In general, it seems that subordinate clauses are important for precise scientific expression. In Greek, thoughts/sentences are usually linked by sentence-modifying adverbs or particles, a trait that scientific Latin sometimes copies; thus, δέ may become *autem*, *vero*, or *tamen*; γάρ *enim* or *nam*; γέ *quidem*; δή *igitur*.[72] It will also be advantageous for scientific expression to be able to differentiate between different degrees of certainty, especially before the advent of modern statistical tools that can quantify probabilities. It would seem that German has especially rich possibilities for this,[73] but this would have to be studied in further depth.

In passing, it may be noted that interestingly (and unintentionally), all these terms for linguistic desiderata of a language of science are based on Latin words. Many of the above, non-linguistic, criteria are too, and the three first and most important ones bear Greek names in modern English. We will return to this topic in chapter 23, where it will become apparent how deeply scientific English depends on the two antique languages. It would be very hard indeed to formulate such criteria using, say, Old English words only (in so-called Anglish).[74]

71 Aikhenvald (2006) discusses languages in which the evidence of a statement must be grammatically expressed. This would seem to be a very useful feature for a language of science. Unfortunately, none of the languages of science has this potentially very useful feature well developed.
72 On Latin adverbs expressing the certainty of the speaker, see Schrickx (2011). She studies especially *nempe, quippe, scilicet, videlicet,* and *nimirum*.
73 In moods (subjunctives), auxiliaries (e.g. *mögen*), and especially adverbs (*ja, doch, wohl, anscheinend*, etc.).
74 There are people who try to use reconstructed Anglo-Saxon to communicate; cf. e.g. the Anglo-Saxon Wikipedia entry on *Witancræft*: 'Witancræft (on Nīwenglisce hātte science) is fandung tō aspyrienne, þurh fandungfæstnesse ("empirical method")' ('*Witancræft* (in modern English called "science") is seeking to discover by the empirical method'; https://ang.wikipedia.org/wiki/Witancr%C3%A6ft, 5 December 2017).

5 The demarcation problem

§1 This chapter returns to the semantic web of terms related to science before modernity, coupling it with the problem of defining and demarcating science from similar human activities today.[1] Chapter 3 has made clear that in Antiquity, science was not yet a clearly defined single concept – it bore several names – but that its principles were known and practised by some. One might say that the epicentre of what would be science for us today lay somewhere between ἐπιστήμη, φιλοσοφία, τέχνη, μάθημα, and ἱστορία. Although we do have a single name for 'science' from the twelfth century onward, science is, of course, still related to similar activities that mostly also go back to antique concepts. Viewed diachronically, this means that we can envisage a complicated and shifting web of concepts around what we tried to define as 'science' in the previous chapter.

Today, the concept 'science' is related to and stands in some kind of contrast to activities such as religion, magic, philosophy, pseudo-science, and technology. It will be best not to look for a single criterion of demarcation to keep science apart from all these other activities, which is likely to be too wide or too strict. For instance, that of Popper uses falsifiability, which would seem to lead to the exclusion of much of even contemporary natural science.[2] Today, the human activity most difficult to separate from science may well be what is variously called pseudo-, crackpot, or junk science. In contrast to the other concepts in figure 4, this one arose only after science had established itself as a crucially important category in life, one that had become worth imitating. Unfortunately, there is a lot of such junk science published these days. Gruenberger (1962) half-jokingly proposed an interesting measure for such 'crackpotness'; the factors it takes into consideration are public verifiability, predictability, controlled experiments, Ockham's Razor, fruitfulness, ability to communicate, humility, open-mindedness, Fulton non-sequitur paranoia,[3] the 'dollar complex', and statistics compulsion. Each of these (or the lack of them) gets a score; the scores are then summed up. The higher the result, the more the author in question is a 'crackpot scientist'. Occasionally, some established scholar or scientist makes fun of junk science tendencies in a field by deliberately publishing junk science that fits into a current mainstream narrative but is completely devoid of scientific content. The most famous example is Sokal (1996); more recently, a paper about 'The Conceptual Pe-

1 In German research this question of demarcating science from similar activities is sometimes referred to as the *Abgrenzungsproblem* (e.g. Schurz 2008: section 2.5.3, whose discussion is used).
2 As Kuhn points out ([1970] 1998: 14): 'If a demarcation criterion exists (we must not, I think, seek a sharp or decisive one), it may lie just in that part of science which Sir Karl [Popper] ignores.'
3 'They laughed at Fulton. He was right. They laugh at me. *Therefore* I must be an equal genius.'

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nis as a Social Construct' (Lindsay & Boyle 2017) poked fun at gender theories very much en vogue today. There is even an algorithm for generating random postmodern articles that sound suspiciously like the real thing.[4] In times when research funding to a unduly large extent depends on fashionable topics, a growing tendency to produce pseudo-science is only to be expected. Pseudo-science may study 'null fields', and '[o]f course, investigators working in any field are likely to resist accepting that the whole field in which they have spent their careers is a "null field"'.[5] But pseudo-science may also just be bad science using methodology that does not yield trustworthy results; Ioannidis proceeds to show with statistical tools that much of our present-day science is not reproducible and therefore wrong, uncovering a very serious problem, especially in medical and psychological research (the 'replication crisis'). New subcategories of pseudo-science have been proposed: 'pathological science'[6] or Feynman's (1985: 338) 'cargo-cult science'; indeed, the study of pseudo-science may itself be growing into a scientific sociological discipline. There are already several encyclopaedias of pseudo-science, although none seems to fulfil scientific and scholarly standards.

Returning to human activities similar to science in general, all of them will use some kind of methodology (as required by item (I)), are to some degree coherent within themselves (IV), and may be based on a community (V). Figure 4 tries to display graphically the fact that words are only meaningful in a semantic field where their relation to other words fixes and thus 'defines' them within a web, as has been pointed out (chap. 3 §1). The illustration shows a tentative web of relationships between these concepts for contemporary English. Of course, such graphics made of simple geometric shapes are but a rough indication of complex relationships between terms. The Roman numerals refer to the non-linguistic characteristics listed above; the linguistic ones taken together would differentiate science at least from much of pseudo- or junk science, magic, and religion, but also from much of philosophy, which tends not to have a standardised vocabulary and may lack *perspicuitas*.[7] A few clarifications are needed. Religion is taken here

4 http://www.elsewhere.org/pomo, by Andreas M. Q. Scuglia. A large-scale project by three scholars to debunk widespread junk science in current academia was https://areomagazine.com/2018/10/02/academic-grievance-studies-and-the-corruption-of-scholarship, by Helen Pluckrose, James A. Lindsay & Peter Boghossian. Compare now the theoretical treatment in Pluckrose & Lindsay (2020).

5 See Ioannidis (2005); for the 'null field', see chap. 4 §4 above.

6 Langmuir & Hall (1989).

7 Heidegger famously said: 'Das Sichverständlichmachen ist der Selbstmord der Philosophie' ('Making oneself understood is the suicide of philosophy'; 1989: 435).

as an explanatory device, not in its many other functions, such as ritual, self-realisation, or social rôles.[8] The distinction between science and scholarship was found above (chap. 1 §7) to be typical for the English language. The main difference in a similar graphic for German or the other modern languages studied in chapter 1 would be that ‘science’ and ‘scholarship’ would form a single concept. To put the graphic into words: philosophy, except ‘natural philosophy’ (which is one of the currents that led to modern science), lacks forms of ‘testing’; technology lacks a theoretical basis; and pseudo-science may lack impartiality, coherence, and/or formalisation.[9] Explanatory religion often lacks non-sterility, the ability to explain step-by-step, and impartiality. As an example of a mixture of pseudo-science and religion in this sense, we could think of biblical creationism, which is currently trying to gain equal footing in the US school system with scientific, evolutionary biology. Of course there will be exceptions within all these fields to all these proposed demarcations, but on the whole and taken together, the above items do seem to be able to delineate quite neatly what science is and what it is not in English today.

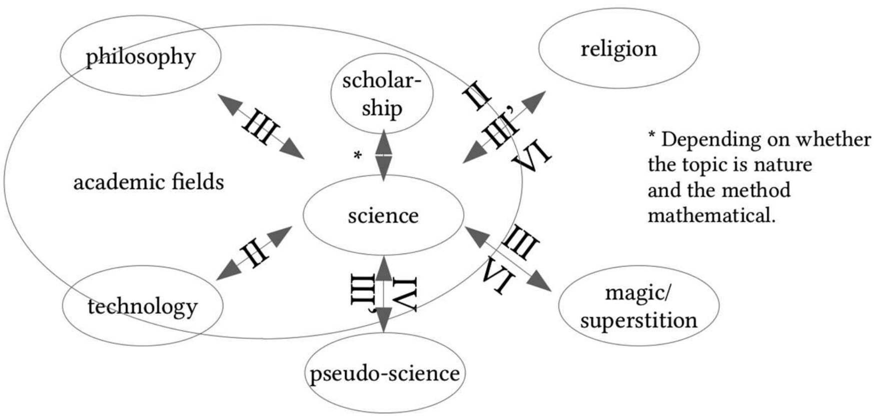

Fig. 4: An attempt to illustrate the semantic field of ‘science’ in contemporary English; see the discussion in the main text.

8 In fact, it may be argued that a single category ‘religion’ encompassing all of these rôles makes little sense outside the Abrahamitic religions. Staal (1996: 401) stresses that ‘[w]e have found that the trio of ritual, meditation and mystical experience consists of categories that are more fundamental than the category of religion itself’.

9 It is interesting to note in passing that technology developed much more linearly from Antiquity to the present day than science. The many technological advances throughout the Middle Ages seem to happen with little theoretical or even scientific background fixed in writing. See Hägermann & Schneider (1991).

§2 Clearly, such webs of concepts shift with time and between languages (chap. 1 §8). If a similar web for the Greek and Latin counterparts of 'science' is attempted (figs 5–6), things look somewhat different. Figure 5 tries to show the web of terms found in Aristotle (see chap. 3),[10] although it must be emphasised that Aristotle does not consciously dwell on these differences and sometimes uses some of these terms as synonyms; he does not deal with magic (μαγεία) either, and he is hardly interested in divination (μαντική),[11] so there are no corresponding terms to English 'magic/superstition' and 'religion'. For him, φιλοσοφία is a very wide term that encompasses everything that produces knowledge and wisdom; νοῦς entails non-discursive knowledge which is not conveyed by and proven within language;[12] ἐπιστήμη consists of three parts: θεολογική, μαθηματική, φυσική; δόξα is its classical opposite as 'unfounded opinion'; αἴσθησις, mere 'sense perception', is also often contrasted to ἐπιστήμη. More strongly, sophistry (what sophists did in classical Greece) may be likened to pseudo-science. ἱστορία is concerned with non-eternal, changing, often individual things and therefore has a lesser degree of certainty, for which it nevertheless strives. Higher τέχνη could be used as a mere synonym of ἐπιστήμη, whereas lower, artisanal, τέχνη is clearly not scientific and not part of philosophy for Aristotle. It must be noted that some of these concepts tend more to denote faculties of the human soul (δόξα) and some more fields (φιλοσοφία), whereas ἐπιστήμη and νοῦς can denote either. These two dimensions should be separated in the web, but this would make the graphic too complex; the same is true for *scientia* in the graphic below.

10 For more details on Aristotle's approach to science, see chap. 7 §5.

11 He treats it cautiously in *De divinatione per somnum*. For a recent study of the rôle and definition of magic in Antiquity, see Edmonds (2019).

12 This Greek word is very hard to translate. LSJ (s.v. I 5b), has '*Mind*, as the active principle of the Universe'; it was the crucial principle of the universe for Anaximander and Anaxagoras. Latin authors often used *intellectus* for it, but νοῦς is not primarily something human. Some mystical authors such as Nicolaus Cusanus use *intellectus* similarly as something beyond man. Bonitz (s.v.) shows for the *Aristotelica notio* (in contrast to the general one and those Aristotle quotes from earlier philosophers) among other things that it is always true (ὁ νοῦς ἀεὶ ἀληθής, ἀληθέστερον ἐπιστήμης, 'νοῦς is always true, truer than ἐπιστήμη'; *Analytica posteriora* II.19, 100b11) and that there is an active and a passive νοῦς, the latter in us and mortal, the μόριον τῆς ψυχῆς ᾧ γινώσκει τε ἡ ψυχὴ καὶ φρονεῖ ('part of the soul by which the soul knows and thinks'); more on this in *De anima* III.4–5, 413b.

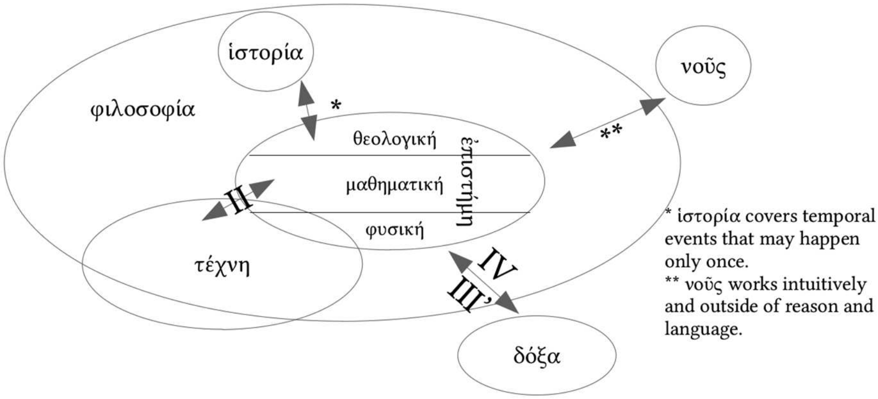

Fig. 5: An attempt to show the semantic web of Aristotle's concepts around 'science'. For details, see main text.

§3 Above, it was shown that many of these Greek terms have found a one-to-one correspondence in Latin. A similar diagram is depicted in figure 6 for Latin, but it must be borne in mind that Latin changed over its long history, so this is at best a strong simplification. Although parts of the graphic look similar to the one before, several things are different: *disciplina* covers a wider field, and *scientia sensu lato* can be synonymous to it; *sensu stricto* it can be synonymous to ἐπιστήμη, and from the mid-twelfth century onward it usually is. The Middle Ages discussed the question of whether *theologia* is a part of *philosophia* or vice versa for a long time, and *scientiae* and (non-manual) *artes* were seen as more or less the same thing and often relegated to a subservient role. The relationship between *philosophia, scientia, ars, and theologia* was hotly debated at least from the twelfth century onward in Latin literature (see chaps 10–11 below). In early modern times, *magia* split into magic proper (*magia ritualis vel daemonica*) and *magia naturalis,* relinquishing powers that have a will of their own ('demons') and becoming a part of *scientia* that helped to render it more experimental (see chap. 12 §4). *Historia,* finally, corresponds not only to our 'history', but also partly to 'scholarship' and to the descriptive sciences like *naturalis historia*, but it is not always clearly differentiated from explanatory *scientia;* or the former may develop into the latter after enough phenomena have been observed and patterns emerge. Of course, the Latin graphic could also be drawn rather differently and contain some more concepts for authors of the early modern period; for instance, Chauvin speaks of *cognitio* a lot throughout his long article on *scientia*, but fails to state how *cognitio* and *scientia* relate. For such authors, *scientia* becomes a very general term for all 'serious' knowledge gathered with sound methodology. Thus, *philosophia*, *historia, theologia,* and *ars* would be encompassed by *scien-*

tia.[13] This is by and large the usage found in the vernacular languages German, French, Russian, and Modern Greek (see chap. 1 above).

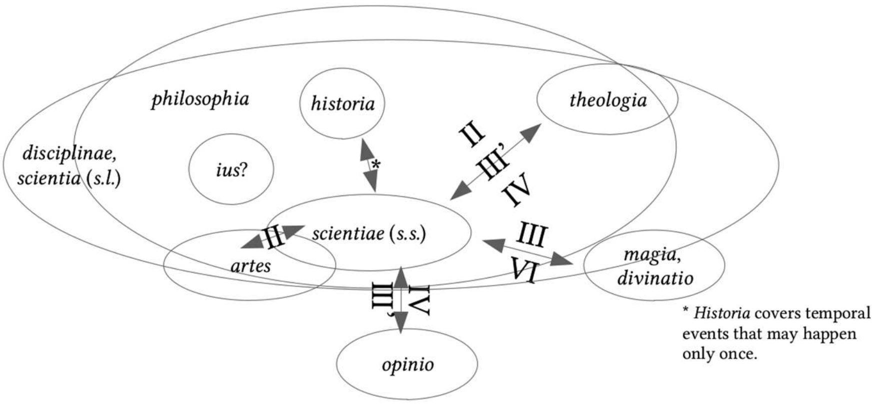

Fig. 6: A similar web for Latin concepts, including *scientia sensu lato* and *sensu stricto*. The exact position of the Latin *ius* within the Greek *disciplinae* remains unclear.

Simplifying matters even more, the following rough semantic correspondences or developments between Greek, Latin, English, and German can be discerned:

τέχνη	*ars*	technology	*Technologie*
ἱστορία	*historia*	scholarship	*Geisteswissenschaft*
δόξα	*opinio*	pseudo-science	*Pseudowissenschaft*
ἐπιστήμη	*scientia*	science	*Wissenschaft*
διδασκαλία	*doctrina*	learning	*Gelehrsamkeit*
?φιλοσοφία	*disciplina*	academic field	*akademische Disziplin*

Although some items in this grid could be positioned differently, it would seem that there is at least a strong diachronic trend linking the concepts. The final set of correspondences is rather tentative, indicating the 'wider frame'. A more diachronic perspective will now be taken, especially for Latin authors through this language's extraordinarily long lifespan. Many of the issues discussed in this first part will become clearer and more nuanced as a result of this examination of the actual textual material.

13 Sanabria (2003: 51–60) discusses various positions regarding the relationship between science and philosophy today. Some Latin passages were discussed in chap. 3 §6 above.

Part 2 Diachronic panorama of Latin science and learning

The first part of this book studied the concept ‘science’ and the associated semantic field in the classical languages, and compared this to usage in some of the main modern languages. A tentative set of criteria was formulated that must be met for an activity to pass as science, applicable from Antiquity to the present. As no one-to-one equivalent term for ‘science’ was found before the twelfth century, it might be argued that science, according to these criteria, did not exist at all in Antiquity and the Middle Ages. Thus, part 2 of this book offers a panorama of potentially scientific (Greek and) Latin authors and sheds some light on their *Denkstil* and their language, both by describing them and by quoting short excerpts. This part of the book provides an overview of the use of Latin as vehicle of scientific thought through, roughly, the two thousand years from Varro to Gauß. Of course, no general history of science in the Latin medium can be offered here,[1] only a selection of Latin authors and their approach to scientific *Denkstil* and the

1 The large works by Sarton (1927–1948), up to and including the fourteenth century, and Thorndike (1923–1958), up to and including the sixteenth century, are the closest to this in existence. A more recent and less ambitious overview of Latin science can be found in Petruccioli (2001–2004: vol. 4).

Latin language. The important issue of the transfer of sciences from one linguistic medium to another will also be raised where appropriate. Scholarly literature will be quoted sparingly, except for groundbreaking works and resources that provide further reading on the subjects discussed. This panorama will hopefully show that the criteria developed above should not be made stricter (otherwise one might lose approaches that do seem scientific or at least seemed so in their time), and that an organic development of science can be discerned between classical Greek times and today. The approach will be chronological and remains largely descriptive. These authors are introduced and situated historically here. Part 3 of the book will then try to establish common ground and differences in the language used by a sample of authors with the help of a corpus linguistic approach.

6 Introductory remarks on *Denkstile*, epochs, and genres

§1 The more one advances in time, the more (and less well studied) texts are found that may qualify for inclusion in our picture. Important, but as yet unedited works survive from Carolingian times onward. The philosophers and scientists of the crucial twelfth century have been studied pretty thoroughly in the past few decades, although this work is still far from complete. From the thirteenth century onward, there is a tendency for individual famous authors to be well studied[1] while the many others are hardly studied at all; especially the fourteenth century is still largely terra incognita.[2] Once the most influential authors stop writing Latin, those who still do are seriously understudied today (except for unavoidable luminaries such as Linnaeus or Gauß). The twentieth-century use of Latin in some niches and in Jesuit teaching has hitherto not been studied at all.[3] This overview will be restricted to authors in the mathematical, natural, and human sciences, and, at some points, in the legal sciences. Even with such restrictions to the less practically applicable, more 'theoretical' kinds of science, such an endeavour must necessarily remain sketchy, but the sample presented will hopefully be representative of the main currents. Medicine,[4] historiography,[5] and theology, in particular, had to be excluded for practical reasons: there is a wide range of genres for all of these fields that would have to be studied separately. The same is true for jurisprudence, but as its language and approach seem to be of special importance for the Romans, its rôle in Antiquity is covered. Thus, this part of the book presents chronologically the typical approaches in the various epochs, the people who can most appropriately be called scientists, the institutions (if any) at which they were active, and what kind of Latin they used. It is often possible to deter-

1 Thomas Aquinas, Albertus Magnus, Duns Scotus, Nicolaus Cusanus, Johannes Kepler, Galileo Galilei, René Descartes, Baruch Spinoza, and Isaac Newton, among others.

2 A terra incognita first sketched by Thorndike (1923–1958: vols 3–4).

3 This is a problem that is not restricted to the study of scientific texts, but is by and large the same in all Latin philology: after Antiquity, studies such as histories of literature become more and more scarce, and from the thirteenth century on they more or less disappear altogether. But the amount of Latin texts produced (and surviving) grows steadily until at least the seventeenth century.

4 For some considerations regarding medicine, see chap. 21. Among the human sciences, we will concentrate on philology and related fields.

5 For some theoretical considerations, see chap. 3 §5 above. There are some studies of the language of historians, at least for Antiquity, such as Cizek (1995). An introduction to the surviving Roman historians from classical times can be found in Kraus & Woodman (1997).

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mine schools or at least groups of authors with a fixed system and epistemological worldview and *Denkstil*. Influxes of ideas and texts from other cultures, especially Greek, are of great importance for understanding some of the changes. For each epoch, a brief introduction stating the general tendencies in society and the typical *Denkstil* in science will precede a more detailed look at some authors and texts, including excerpts illustrating their language. The end of each chapter considers the extent to which the criteria for science established above (chap. 4) make sense for the authors and schools considered.

Unfortunately, there is quite generally a trend among scientists not to address the language they employ unless it is either unusual or endangered by another new one. Thus, it will be seen that the late republican Romans (especially Cicero) address this topic because Greek was *the* language of philosophy and science, and in the eighteenth century when French is about to eclipse Latin the topic is again often discussed: authors who use Latin may justify their use; those who eschew it give reasons for its perceived unfitness.[6]

§2 The entire lifespan of Latin in the function of transmitting scientific content seems to be most fittingly divided into seven epochs exhibiting different *Denkstile* and sometimes also different types of language: they will be treated in as many chapters below. As 'it is inevitable that periodizations will vary according to the themes broached' (Inglebert 2012: 5), some of the proposed divisions may look unfamiliar. (i) In classical Roman Antiquity, 'serious' scientific matters were usually treated in Greek and those authors who used Latin did so for a specific reason, be it to prove that Latin was capable of fulfilling this function (such as Cicero), or for reaching a larger audience (such as Pliny), or for treating a field that was typically Latin (such as the Roman jurists). This is the time when the Greek scientific *Denkstil* was first imported into Latin, although in a fairly diluted, Romanised form, and its success was not lasting. (ii) In Late Antiquity, the dynamics change to some extent, as on the one hand knowledge of Greek is dwindling in the Western part of the Roman Empire and on the other hand a Christian *Denkstil* becomes prevalent, with a tendency to perpetuate the insights of the Greek scientific *Denkstil* in compendia and collections of what is already known; it may generally be described as relatively static. In this time, the *artes liberales* become the central classification scheme for much of science. This state of affairs continues into the Early Middle Ages, with a new revival in Carolingian times. Authors up to the twelfth century tend to be more of a didactic and less of an investigative scientific nature in many (but not all) fields, and their thought is rooted in Christianity's worldview. So, for

6 This point is also stressed by Gordin (2015b: 200).

the study of science it makes sense to treat this age of the *artes liberales* from Christian late antique Rome up to and including the eleventh century as a single epoch. (iii) The long twelfth century sees new teaching methods stressing dialectics, and with this a revival of investigative science and of natural-philosophical speculation (what could be called the Greek scientific *Denkstil*), both among Platonists and, especially with the advent of Aristotle translations, among Aristotelians. This century is the turning point for all the later development of science in Latin: many different approaches are tried out in various fields and schools. For the first time, some Latin authors discuss *scientiae* as a group of related fields of study, very much as we do today. (iv) This diversity is reduced at the new universities of scholasticism, but its mainly Aristotelian approach is at the same time deepened and fully developed. Aristotle's newly accessible *Analytica posteriora* becomes fundamental for the scientific method. We can speak of an Aristotelian Revolution or a Latinised version of the Greek scientific *Denkstil* for the first time. The Latin used also changes strikingly. As largely authority- and logic-based science, scholasticism remains the standard until the fifteenth century, and in some fields well beyond. (v) In Renaissance times, there are again several new *Denkstile* vying for success: many of them are influenced by a renewed influx of texts and ideas from Greek, especially an anti-Aristotelian Platonic reaction that strives for a more holistic, mystic type of science; on the other hand, experimentally minded *magia naturalis* is also developed in this time. A further important current are Ciceronian language purists, anti-scholastic humanists, although they prove to be more a step backward for science. (vi) The Scientific Revolution acquires from this *magia naturalis* a more experimental turn, but methodologically and language-wise the *Denkstil* largely remains Aristotelian in many fields. A consciousness of novelty is typical for this time. This attitude starts to gain the upper hand around AD 1600. From the seventeenth century onward, we see fast progress in many scientific fields, which justifies the label 'Scientific Revolution'. (vii) Finally, we can speak of post-Latin science: the use of Latin as the international language of science lost its dominance in the eighteenth century. This process led to a hegemony of three European vernaculars: French, German, and English. Vestiges of the use of Latin in the time since then will be examined, as well as the transfer of science into the vernaculars. The Latinised Greek *Denkstil* did not change much in this period or since, but new results have produced many minor revolutions in many fields; indeed, one can say that science as a whole became revolutionary in the time of the Scientific Revolution.

Even this overview shows that there are times with strongly differing scientific tendencies or schools that use strikingly novel methodologies and approaches; with Fleck, we can speak of *Denkstilumwandlungen* (i.e. the beginning of Roman science, the twelfth and the fifteenth centuries) alternating with times where one specific approach is deepened. This larger picture fits well with a Kuhnian approach to science (itself an offspring of Fleck's ideas) as either 'normal' or 'revolutionary'. But, as usual with reality, there are more details if we look more closely. For instance, the school of mathematical empiricism championed by the Scientific Revolution has still not been able to supplant all other approaches in many fields, even today. The struggle between *Denkstile*, methodologies, and languages in science has by no means ended. The standard language of science also has its 'normal' and 'revolutionary' phases. In the former it is a single stable and widespread language;[7] in the latter there are many contestants for a new standard. In revolutionary phases, much ballast but also much real insight is swept aside. Of course, the stable phases may be of very different duration. The only recently established world hegemony of English may or may not survive the likely demise of US world dominance in this century, begging the question 'would we not have been better sticking with Latin?'

Latin as a language of science is very much dependent on Greek, its predecessor in this rôle. Indeed, Latin science takes input from Greek texts and/or from Greeks at several pivotal times in its history until the fall of Constantinople (1453). The four main phases of Greek influx are schematically depicted in figure 7; they correspond to the times of Cicero, of Boethius, the twelfth century, and the fifteenth century. Incidentally, the graphic hints that Latin science did not die off in the Latin Early Middle Ages (as is sometimes claimed); what happened is rather that the coherence with the Greek writing community in the East was all but severed. The most important influxes leading to *Denkstilumwandlungen* clearly happened in the twelfth and fifteenth centuries, the latter case ending when Greek ceased to be used as a language of science after the fall of Constantinople. Nonetheless, Greek scientific texts continued to shape the development of Latin science for at least another century and were important in the Scientific Revolution. For these reasons, Latin science cannot be treated in a manner fully detached from Greek science, and the panorama must begin with a summary of the developments of scientific tendencies and schools within Greek in order to provide the background for what follows.

7 On a large temporal and spatial scale, this privilege has been granted to very few languages in human history, possibly only Greek, Arabic, Latin, French, German, and English.

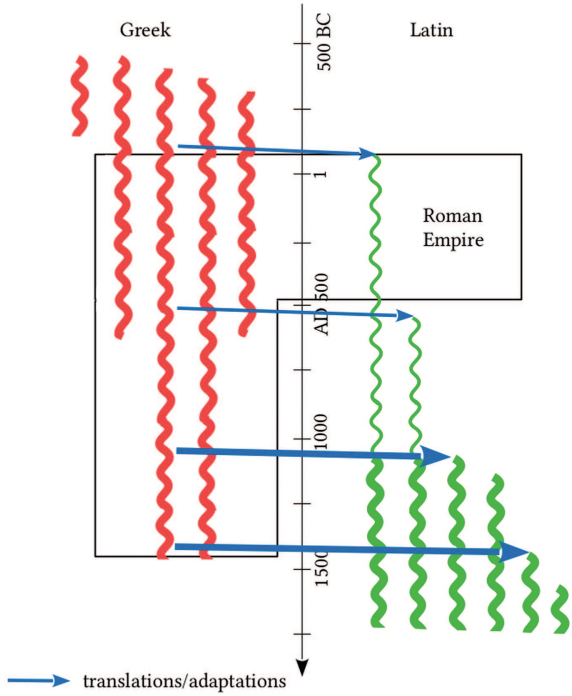

Fig. 7: The four main phases of Greek 'input' into Latin science, represented schematically. Greek scientific texts are in red, Latin ones in green.

§3 This part of the study will begin with a look at what genres of scientific texts were used in the ancient languages, as the options for scientific writers back then were much wider than they are today; there was no single typical genre for science. There are similar cases in other kinds of literature, for instance hagiography, which used an entire 'fédération de genres' (Cizek 1995: 12; see below). Mediaeval hagiographic texts could be written in verse, rhythm, or prose; they could describe the saint's *vita* fully, or only his or her *passio* or miracles; the *inventio* or *translatio* of his or her relics made further genres. Martyrologies and calenders collected information about various saints. Despite these and other possibilities, hagiography is still a relatively clearly defined field of study, including some typical linguistic traits.[8] Scientific knowledge – as well as other types of knowledge and skills – has similarly been propagated by various means, from exclusively oral master–pupil teaching to various kinds of written texts. In a historical context, we

8 More details in von der Nahmer (1994).

have to deal with the latter. The main distinction there will be between propadeutic, didactic, and even propagandistic texts on the one hand and texts that are written by experts for other experts on the other; these latter will differ from the former in many respects. The first kind of texts will use types of language that are more or less effortlessly understandable for lay people and will try to make the language pleasant and the reading attractive, whereas authors who write texts of the second type will usually not bother much with such things; they will at least not endanger the precision of their content by taking good style into account.

In Antiquity and the Middle Ages, these differences were a lot less clear-cut than they are today, but they did exist. In German this difference is expressed in the rhyming terms *Sachbuch* ('book about a topic') and *Fachbuch* ('technical book').[9] The textbook for students, German *Lehrbuch*,[10] may be seen as an intermediary between these two types. Only the *Fachbuch* type tends to quote its sources and to trace the path of its reasoning fully. Fleck (2015: 148) proposed a similar classification of scientific depth from esoteric to exoteric for his own time: *Zeitschriften-*, *Handbuch-*, *Lehrbuchwissenschaften*, *populäres Wissen*. Types of texts correspond to these types of science. The first is still in flux, debated and tentative; the second becomes a fixed body of science; the third teaches; and the fourth is what has become assimilated by society at large. In Greek and Latin texts, the first two categories are not differentiated clearly before scientific journals become important in the second half of the seventeenth century. Before then such communication was often shared in letters between scientists. Such 'private' literature does not survive from Antiquity; in the Middle Ages we have the first surviving letters that might be called scientific, for instance from Lupus of Ferrières in Carolingian times (chap. 9 §11). The Noscemus project led by Korenjak[11] distinguishes the following text types for early modern times: bibliography, biography, commentary, dialogue, dictionary/lexicon, didactic poem, dissertation, encyclopaedia, *historia*, journal paper/review, letter, monograph, oration, panegyric poem, report, tables and charts, textbook, and translation.

§4 Now, Fleck's classification is clearly intended for post-Latin times and Korenjak's for Early Modern Latin ones. We will not try to present a fitting classification for the entire time span covered here; instead, only the most important genres are briefly reviewed. This is important, as the different genres are likely to use somewhat different language, which will be taken into account in chapter 18 when var-

9 Used e.g. by von Albrecht (1992–1994: 1:452–453).

10 On which in Antiquity, see Fuhrmann (1960).

11 https://wiki.uibk.ac.at/noscemus/Main_Page . See chap. 13 §4 for more details about the project.

ious texts are linguistically compared. The following types thus constitute neither a complete survey nor a closed system; they are merely descriptive and not exhaustive. A first obvious division is that between prose and verse. In fact, an entire, major genre of the latter existed in the classical tongues: didactic poetry, which usually used hexameters.[12] Some examples are considered briefly here, but poetic texts will be marginal in the rest of the book. Didactic poetry follows clearly defined conventions from early Greek times onward that have changed little, if at all, during the lifespan of Greek and Latin and that developed in strong contrast to epic poetry (which is also hexametric): didactic poetry generally lacks dialogues, gods, and *ornatus*, and excursuses are either absent or subordinated to its didactic goals.[13] After Hesiod's *Opera et dies*, teaching his brother agriculture, this genre is first seen in a 'scientific' form among early Greek thinkers such as Parmenides and Empedocles. In Hellenistic times, more technical science had already become confined to prose, but the poetic form is taken up in Rome by Lucretius. Subsequently, it keeps being used through the ages until the demise of Latin as the international form of communication. A few more representative Latin authors (whose texts will be used in chap. 20 below) can be named to illustrate the wide range of topics for which verse was employed. Early in the first century AD, Manilius, an author about whom nothing is known, wrote a rather technical didactic poem about astrology,[14] Avienus Rufius Festus (fl. 360) wrote two geographical poems: a *Periegesis*, translated from a lost Greek work, and the *Ora maritima*, also strongly dependent on lost Greek sources. Didactic poetry is, again, widespread from the Carolingian renewal onward; for instance, Walahfrid Strabo writes a botanic poem *Hortulus*.[15] In the eleventh century, the anonymous *Kräuterbuch* known as *Macer Floridus* is written; in the twelfth, Bernardus Silvestris writes his *Cosmographia* in prosimetrum. The genre possibly thrives even more in early modern times. The controversial Marcellus Palingenius Stellatus' (ca. 1500–1544) *Zodiacus vitae* on a scientifically led life arranged according to the twelve signs of the zodiac and including satire against both Catholics and Protestants can be mentioned. Still in the sixteenth century, the hermetic philosopher Giordano Bruno follows Lucretius in many aspects in his mystical poems on the universe, *De monade, numero, et figura*. Toward the end of the eighteenth century,

12 For an overview of Latin didactic epic, see Korenjak (2019); Haskell (2003).
13 See Pöhlmann (1972–1973: 898–900).
14 According to our criteria above (see chap. 4 §5), astrology still qualified as a science then, that is to say until it became out of tune with the other sciences of the heavens with the advent of the Copernican heliocentric worldview. Indeed, its texts, such as that by Manilius, use language and ways of reasoning that are compatible with the other sciences then practised.
15 On didactic poetry in the Latin Middle Ages in general, see Haye (1997).

the Ragusan Jesuit Benedictus Stay wrote a lengthy poem on Newtonian physics (*Philosophiae versibus traditae libri sex;* some 11,500 lines) and another poem trying to reconcile Descartes's worldview with Christianity (*Philosophiae recentioris versibus traditae;* some 24,000 lines). At the same time, his fellow Ragusan Bernardus Zamagna (1735–1820) wrote a didactic poem about air ships (*Navis aeria*) in 1768, fifteen years before the famous flight of the Mongolfier brothers. The language used by most such antique and early modern authors consciously follows that of Lucretius very closely. The numbers in chapter 20 below show that for late antique and mediaeval authors, this is somewhat less the case. In early modern times, the great importance of learning to write Latin poetry was similar to that of imperial Roman times: it was seen as a school for all further intellectual activity. For instance, Philip Melanchthon states (*Epistola* 433, ed. Scheible, vol. 2, p. 368):

> *Nam mihi quidem de nullo disciplinarum genere recte iudicaturus videtur, qui poeticen non attigit, videoque in soluta oratione scribenda mirifice frigere illos, qui non degustarunt poeticen.*
> 'For it seems to me that someone who has not tackled poetry will not judge correctly about any scientific discipline, and I see those who have not tasted poetry to be strangely frigid when writing prose.'

Despite their great numbers, scientific works in verse already served mostly didactic purposes (sometimes also crossing over into satire) in Antiquity after Plato and Aristotle. The Latin examples mentioned above are often closely modelled on Greek predecessors and can be seen as propagating Greek science to a wider audience. The preference of prose for innovative science becomes even greater when the universities in the thirteenth century become the major locus for science. In the time of the Scientific Revolution, poetry is frequent only in dedicatory poems at the beginning of scientific works.[16] In the vernacular tongues, this form of scientific communication does not seem to have been successful, and this genre may safely be said to be completely extinct in contemporary science.[17] Didactic and scientific poetry is not central in this study. Its language is only briefly touched upon in the corpus study in chapter 20 below, where it will become clear that it differs markedly from prose scientific Latin.

Another genre that is usually didactic in nature is the scientific dialogue. The first and most important model for this kind of literature is Plato. It also remains very common throughout the entire time span under consideration,

16 Compare the lists of crucial works of the Scientific Revolution below (chap. 14 §§2–3); they contain not a single work in verse.
17 Korenjak (2019: 143) sees the reason for this in Romanticism, which believed that poetry should 'not even try to teach the reader something'.

starting with Cicero in Latin, and it is especially popular in the Middle Ages.[18] Often the dialogue partners are a teacher and a pupil, or the author and an adversary holding the view the author wishes to refute; thus the interlocutors accompany the reader in gaining knowledge. For instance, Eriugena's *Periphyseon*, discussed below (chap. 9 §11), is written in dialogue form between teacher and pupil. A later famous vernacular example is Galileo's *Dialogo dei massimi sistemi;* it is an example of the second type. Often the dialogue form seems somewhat artificial: the pupil only occasionally asks a question, which could just as well be a mere title for the following teaching by the master. Indeed, the kind of Latin used is often similar to that of treatises. After the demise of Latin as the language of science, this genre becomes rare; there are hardly any specimens today.[19]

Once the amount of learning becomes difficult for a single individual to master, the encyclopaedic genre will come into existence quite naturally. The most important surviving encyclopaedia from Latin Antiquity is clearly Pliny's monumental *Naturalis historia*; for the Middle Ages, Isidore's *Etymologiae* then became very popular. In the thirteenth century, there is a whole plethora of new encyclopaedias trying to get to grips with all the new learning (especially between 1190 and 1260; see chap. 11 §4). Of course, there were also encyclopaedic treatments of single fields, such as Celsus' on medicine (the books in which he treated other arts are lost). These Latin encyclopaedias are thematic. Alphabetical order was used rather for fields that do not have a clear inherent logical structure, such as language, and thus for dictionaries (already in Antiquity, e.g. in Verrius Flaccus' *De verborum significatione*). This genre would stand between Fleck's *Lehrbuchwissenschaft* and *populäres Wissen*.

The scientific treatise (πραγματεία, *tractatus, tractatio*, *commentatio*) on a subject by an expert written for other experts – what today is called 'research science' – is certainly the genre in which one would expect that scientific novelty is most likely to be born, that authors strive most vigorously and with the least compromise to adapt their language to their way of thinking. Such treatises of a more or less scientific kind can already be glimpsed among the fragments of several pre-Socratic philosophers and among some Hippocratic writers quoted below, but it is Aristotle who was to be most influential for this genre: he wrote numerous treatises (see chap. 7 below). He writes an unpretentious, matter-of-fact prose that is usually as clear as possible while not shirking away from the compli-

18 For the Late Middle Ages, see Cardelle de Hartmann's (2007) inventory, especially 58–103.

19 Fleck wrote a dialogue in 1946 (originally in Polish; German translation in Fleck 2011: 373–386), inspired by Galileo's famous dialogue between Simplicius and Sympathicus on the nature of scientific truth. Pörksen (1999: 660–662) wrote another one on the advantages of science in Latin as opposed to the vernaculars.

cated details and not disdaining to admit that a certain point needs further research. As far as we can see now, scientific treatises in Latin begin with Varro, but surviving treatises that can be called fully scientific are to be found only much later, possibly as late as Boethius, who consciously imitates Aristotle's style in his works on logic. This Aristotelian style will become common in scholasticism. The scientific treatise corresponds to both Fleck's *Zeitschriften*- and *Handbuchwissenschaft*. The letter on scientific topics between scientists may be seen as a subcategory, for instance often used by jurists to articulate their expertise. In the twenty-first century, this genre has been replaced by the usually very informal e-mail.

Another important genre, especially in the Middle Ages, are commentaries (ὑπόμνημα, *commentarius*) on important scientific texts. This genre seems to develop out of the much more common commentaries on holy texts (such as the Bible for Christians or Plato's dialogues for neo-Platonists). Examples are Boethius or Albertus Magnus commenting on Aristotelian works. In times when authority was more esteemed than novelty, this medium was often chosen to present and downplay new ideas developed out of the study of an older, authoritative writer. In scholastic theology, commentaries on Peter the Lombard's (ca. 1096–1160) *Liber sententiarum* often did little more than follow the most general layout of the *Sententiae*, but developed very different ideas. As such a commentary was required to obtain a *magister*'s degree in theology, there are enormous amounts of them surviving. In early modern times, when the premise of the greater importance of authority as opposed to innovation shifts, this genre becomes less popular. But the Italian mathematician Bernardino Baldi, for instance, still wrote a scientific commentary to (Ps?-)Aristotle's *Mechanica* (*In mechanica Aristotelis problemata;* Moguntiae, 1621) in the seventeenth century. Scholarly and didactic commentaries to fundamental works, of course, remained important even later, for example the Latin commented edition of Newton's main work from 1833 (Newton, *Philosophiae naturalis*). We have already mentioned the importance of translations of scientific works, especially from Greek, in certain times; they constitute their own genre with special rules, for instance concerning the technique of translating. They were often accompanied by commentaries (see chap. 10 §5 below). Treatises on practical arts by practitioners for practitioners were in Late Antiquity often written in unpretentious Latin, approaching the spoken language ('Vulgar' Latin): for instance, the veterinary text *Mulomedicina Chironis* (fourth century) or Anthimius' diatetic text *De observatione ciborum* (early sixth century). The language of these texts is already clearly distinct from literary Latin, and they are not included in the text samples below. From the Carolingian period onward, Latin had to be learned in school by everyone and such 'Vulgar Latin' texts no longer exist, but some authors still wrote unusual, substandard Latin. In our samples used below (chaps 18–20), this is the case for the historiographer Iohannes de Plano Carpini, the didactic poet of the *Macer Floridus*, and the medical writer Bernardus de Gordonio. On the whole, such Latin authors were rare; science was and is something that tends to be performed by people who attended good schools and wrote accordingly.

This should suffice to cover the main examples of the wide variety of genres science could be written in. In contrast to many other facets of writing, Antiquity did not set down clear rules for the writing of scientific texts in general, a fact that may be linked to the absence of a clear concept 'science' (as shown above in part 1). So, other genres, such as those mentioned above, could be chosen by authors, taking literary conventions over from them quite freely. For instance, an antique literary genre strongly influencing the development of scientific prose is *ecphrasis,* in which a plastic, precise, and satisfactory description of something is central. Only the scientific fields of greatest importance in society developed their own styles and conventions, most notably jurisprudence (see chap. 8 §12) and historiography,[20] as did Greek logic and mathematics.[21] Apart from these, medicine (see chap. 21) at least developed its own technical terminology, as theology, logic, and scholastic philosophy were to do in the later Middle Ages. Such scientific technical languages may develop so far that special dictionaries for them become necessary. The existence of such specialised dictionaries can be taken as an indicator of the development of a scientific field's terminology and, hand-in-hand with this, of the science's level of sophistication. There are special Latin dictionaries for jurisprudence (such as the *Vocabularium iurisprudentiae romanae* and Seckel's *Heumanns Handlexikon*), for Latin medicine the recent *DILAGE*, covering at least some parts of medical Latin,[22] and for scholastic logic and philosophy Schütz's *Thomas-Lexikon*. The usual genres of historiography are not characterised so much by their vocabulary, so no special dictionaries are necessary; the basic terminology of mathematics in Antiquity is mostly covered by the general dictionaries and now by Guillaumin (2020); for later times (after Isidore) there is no modern dictionary[23] – as for so many other facets of Post-Classical Latin.

20 Its mediaeval genres are studied by Hofmann (1987). Cizek (1995: 12) rightly speaks of a 'fédération de genres'. He presents a table with the following (339–341): *annales*, *res gestae*, *historia*, *histoire universelle*, *épitomé*, *tableau chronologique*, *monographie*, *mémoires*, *biographie*, *exitus*.

21 On genres of surviving Greek mathematical texts, see Acerbi (2010: 16–21). See further on this topic chap. 22 below.

22 A general dictionary of medical Latin is a desideratum.

23 But there were contemporary ones such as Dasyposdius, *Λέξικον seu dictionarium mathematicum,* in both Greek and Latin, though not in alphabetical order.

Below (chap. 8), it will become clear that in Roman times Latin was nearly completely confined to being used for didactic scientific texts, whereas Greek was used for 'serious' exchange between advanced scientists (especially for scientific treatises). The linguistic studies below will try to focus mainly on the language of these strictly scientific texts, although also making use of more general texts, as there are hardly any surviving texts of the 'by scientist for scientists' type in Latin before the twelfth century. Indeed, the corpus used in chapter 18 consists of texts of most of these genres, with the aim of seeing to what extent their language differs. It will become clear that Aristotle's kind of language will become the rôle model for scientific writing in many fields not only within Greek but also Latin, and to some extent still in the vernaculars today.

7 Greek science and its language in Antiquity

> Greek has been as hard to keep away from Latin as the sons of Israel from the daughters of Canaan.
>
> Dirckx (1983: 106)[1]

§1 Although this study is concerned with Latin, a brief chapter on its precursor language in Antiquity is indispensable due to the significant influence of the latter on the former. All through the history of Latin up to the fall of Constantinople (1453), Greek continually influences Latin developments, as the motto quotation points out. This chapter will be limited to considering early candidates for being called 'scientists' (§§2–3), Plato (§4), Aristotle (§§5–6), and Hellenism and some glimpses of later developments (§7).[2] Chapters 3–4 above have already traced the Greek word ἐπιστήμη and its semantic field, mostly using the two authors most influential for epistemology and science in later times: Plato and Aristotle. We found that our modern categories of science, philosophy, religion, magic, technology, and the like (as used in chap. 4 §8 above) did not yet exist separately in early Greek thought; rather, they can be said to be *in statu nascendi* from earlier 'lore'.[3] This is the time and the environment in which the Greek scientific *Denkstil* is born; in Aristotle and Hellenistic scientists, it is already found in a very developed form. What many of the earlier authors quoted in the next few sections did and taught may at best belong more to one of our modern categories and less to others. So, while there are a number of important scientific insights and new methodologies in early Greek times, few of the men involved could be called 'scientists' first and foremost.

Concerning the relationship of language and science, the Greeks themselves in classical times do not show much interest in foreign languages (spoken by βάρβαροι)[4] – consequently, they are hardly ever conscious of differences between the use of their own language and others. The importance of language in convincing

1 In a somewhat different context, speaking of Greek and Latin words and parts of words in English.

2 Lloyd (1970, 1973) provides general introductions to the study of Greek science before and after Aristotle respectively. Clagett (1955: 22) similarly proposes four periods for Greek science: 'pre-Socratic', Plato/Aristotle, Hellenistic, Roman. Remarkably, his book treats Greek science in Roman times down to AD 600 in detail too.

3 Cf. the title of Burkert (1972).

4 See Momigliano (1975). Aristotle, *De philosophia,* frag. 35 Rose (from Diogenes Laertius, *De vita philosophorum* I.1, ed. Long, vol. 1, p. 1) apparently did mention: Τὸ τῆς φιλοσοφίας ἔργον ἔνιοί φασιν ἀπὸ βαρβάρων ἄρξαι ('Some say that the work of philosophy begun among the barbarians'). But language is not mentioned in the surviving fragment.

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people of one's own point of view is one of the main points of the sophists (§3), but inherent limitations of natural language are a rare topic among Greek scientists; indeed, the Greek language seems singularly apt to being easily extended for scientific use (see chap. 22). Such limitations are more often discussed by later mystics, who stress the ineffability of their experiences. Examples are Plotinus or, more importantly for the Latin development in the Middle Ages, Dionysius Areopagita, who among other things states about the transcendent God (*Mystica theologia* 5, ed. Heil & Ritter, p. 150):

> οὔτε λόγος αὐτῆς [i.e. τῆς πάντων αἰτίας] ἐστιν οὔτε ὄνομα οὔτε γνῶσις.
> 'there is no reasoning about it [the first cause, i.e. God], not word, nor knowledge.'

Church Fathers such as Augustine also often stress the ineffability of the divine.[5] From this ineffability, Eriugena will conclude that God 'is' not, but 'is' superessentially (*Periphyseon* III.5, PL 634B–C = ed. Sheldon-Williams, vol. 3, p. 60):

> *Si igitur propter ineffabilem excellentiam et incomprehensibilem infinitatem diuina natura dicitur non esse, nunquid sequitur omnino nihil esse dum non aliam ob causam praedicetur non esse superessentialis nisi quod in numero eorum quae sunt numerari eam uera non sinit ratio dum super omnia quae sunt et quae non sunt esse intelligatur?*
> 'Therefore, if it is on account of its ineffable excellence and incomprehensible infinity that the divine nature is said not to be, does it follow that it is nothing at all, when not-being is predicated of the superessential for no other reason than that true reason does not allow it to be numbered among the things that are because it is understood to be beyond all things that are and that are not?' (Trans. Sheldon-Williams, p. 61)

An introduction to the field of the language of the *via negativa* can be found in Westerkamp (2006). In contrast, the Greeks hardly spoke about the advantages or disadvantages of their language for science or philosophy.

'Pre-Socratic' 'science'[6]

> In coming to understand and explain, they rarely used careful observational data, or experiments, in support of their claims. Nevertheless, the problems that the Pre-Socratic philosophers identified, and with which they grappled, largely by abstract, rational arguments,

5 e.g. *De doctrina christiana* I.6(6), ed. Green, p. 11.
6 The new edition of all relevant texts by Laks & Most rightly avoids the traditional term 'pre-Socratic'; the general picture is heavily distorted by claiming that Socrates changed philosophy radically and single-handedly.

> formed the basis of natural philosophy as it would be shaped in the fourth century BC by Aristotle.
>
> Grant (2007: 18)

§2 Exploring the first scientific achievements *sensu stricto* is made difficult by the fact that very few primary sources of the authors in question survive in full; for those in the sixth century BC, no complete text at all has come down to us. As a consequence, there is little concord on these authors' scientific approach (or lack thereof), which also depends to a large degree on one's definition of 'science', as pointed out above (chap. 4). A comparison with extant Middle Eastern and Egyptian texts from the second and early first millennium BC show clearly that in Greece around the sixth century a new inquisitive, 'scientific' *Denkstil* emerges. The extent to which it makes sense to see science as the further development of this Greek *Denkstil* is discussed at the end of this book (chap. 24).

The earliest philosophers often credited with the invention of 'science' and philosophy lived and taught at their own private schools in the Ionian city-states of the sixth century,[7] beginning with the Milesians Thales (ca. 624–ca. 546), Anaximander (ca. 610–ca. 545), and Anaximenes (ca. 585–ca. 528) and continuing elsewhere in this melting pot of Greek and 'oriental' cultures (especially Babylonian, Assyrian, Lydian, then Persian), such as Samos (Pythagoras, ca. 570–ca. 510) or Ephesus (Heraclitus, ca. 520–ca. 460). Upon the Persian conquest, some of these men emigrated to southern Italy, where they continued to flourish in various schools (especially Pythagoras, Xenophanes) and produced new approaches (e.g. Empedocles, Parmenides).

There are two points of uncertainty: first, how much of the early Greek (e.g. Milesian) 'science' stemmed from oriental sources mostly inaccessible to us,[8] and second, how much of it was actually 'science' and not just backward projection by later doxographers. The early oriental cultures are known for their 'wisdom' literature, which is clearly not of a scientific character.[9] A typical example of a scientific feat is the alleged prediction of a solar eclipse by Thales, who was in the

7 For a summary of the historical background of these cities at the crossroads of many cultures, see Marek (2010: esp. 177–183).

8 West and Burkert have changed our knowledge of these contacts decisively. See e.g. West (1971, 1997) and Burkert (1969a, 2008), where the regional political background, especially the Assyrian conquests and the large number of displaced people in these times, is emphasised as the background against which Greek thought first becomes palpable for us.

9 There is a brief introduction in Burkert (2008: chap. 5).

past often hailed as the father of science precisely for this.[10] It seems clear now that such a prediction would have been unthinkable even for the Babylonians, who were in possession of astronomical data spanning centuries, and much more so for a Milesian, who could hardly have had access to records of past eclipses necessary to predict future ones,[11] at a time when the sphericity of the Earth was still unknown and thus also *a fortiori* the mechanism of eclipses. Indeed, it can be shown how already in Antiquity, this myth developed out of an untrustworthy statement by Herodotus.[12] Pythagoras and the Pythagoreans are often credited with the invention of the sciences of mathematics and music theory, although hardly any of their achievements can be confidently dated back to their founder or his first pupils.[13] Heraclitus might be taken to attest (although not to approve of) Pythagoras' scientific learning when speaking scornfully about his πολυμαθίη (D20 LM = 40 DK), but he mentions it together with Hesiod's 'learning' about the gods, which will not qualify as scientific in any way. In fragment D26 LM = 129 DK, Heraclitus speaks of Pythagoras as practising ἱστορίη, which again leads to his πολυμαθίη but also κακοτεχνία ('malpractice', with a connotation of fraudulence). Pythagoras and his early followers can be contextualised well as a kind of shamanic miracle men,[14] but that they engaged in activities that deserve the term 'scientific' must remain at best conjectural.

Nonetheless, many of those sages did set out to study φύσις and are accordingly called φυσιολόγοι. Although this concept roughly corresponds to our 'nature' (which is studied by natural science), it has some slightly different connotations: φύσις contains everything that grows or, indeed, comes to be (ἃ φύεται), thus the entire phenomenal world. The mystical and religious character of this

10 The tradition of beginning philosophy and science with Thales and his pupils goes back to Diogenes Laertius (*De vita philosophorum* I.13, ed. Long, p. 5) and tends to be upheld by many modern writers, such as Lloyd (1970: 8).

11 Not to mention the necessary mathematical skills; see Neugebauer (1970).

12 As done in Mosshammer (1981). It is interesting to note that science has a tendency to produce hagiography and mythology for some of its 'heroes' (e.g. Galileo and the wrong idea that the Middle Ages thought the Earth was flat, respectively). Science should not be made a pseudo-religion, just as religion should not be pseudo-science.

13 The following largely follows Burkert (1972: 208–217, for mathematics: 401–420). See also von Fritz (1955).

14 Burkert (1962). The Greek term γόης comes close to our modern notion 'shaman' (which is abstracted from Siberian practices); the comparison goes back to Meuli (1935). Jan Bremmer voiced his disapproval, against which Burkert argues convincingly. Burkert also observes 'merkwürdig oft wird γόης und σοφιστής verbunden' ('remarkably often, γόης and σοφιστής are connected'; 1962: 189).

vast entity was rightly pointed out already by Cornford (1912).[15] Thus, this 'all' is not far removed from what the neo-Platonists will call πλήρωμα: a divine, self-enfolding totality of being. This is what the φυσιολόγοι tried to understand, at first with approaches that can hardly qualify as scientific except, perhaps, insofar as there was a critical spirit and free debate among the sages.[16] In fact, some of the most renowned sages of the sixth century were already combined into a group in Plato's time: the 'Seven Sages', whom Plato lists as Thales of Miletus, Pittacus of Mytilene, Bias of Priene, Solon of Athens, Cleobulus of Lindus, Myson of Chenae, and Chilon of Sparta (*Protagoras* 343a). They are by and large more statesmen or law-givers than philosophers or scientists, and provide another hint that Thales should rather be seen in that context too. Lloyd sees science's birth in the rejection of magic, a term he understands in a wide sense. He thus sees its novelty in the will to find necessary causes of phenomena. Some fragments from the Ionian philosophers indeed appear to indicate their preoccupation with principles and causes. About Anaximander we hear (P5 and D6 LM = A9 DK, known from Theophrastus):

> Θαλοῦ γενόμενος διάδοχος καὶ μαθητὴς ἀρχήν τε καὶ στοιχεῖον εἴρηκε τῶν ὄντων τὸ ἄπειρον, πρῶτος τοῦτο τοὔνομα κομίσας τῆς ἀρχῆς. λέγει δ' αὐτὴν μήτε ὕδωρ μήτε ἄλλο τι τῶν καλουμένων εἶναι στοιχείων, [...].
> 'Having become disciple and successor of Thales, he claimed that the boundless [τὸ ἄπειρον] was the beginning and fundamental principle of what is; he was the first to use the term "principle" [ἀρχή]. He says that it was neither water nor any other of the so-called elements, [...].'

We have seen (chap. 3 §11) that legal terms such as αἰτία/αἴτιον ('guilt; responsibility; cause') acquired a philosophical and scientific meaning, shifting from being 'responsible, culpable' for something to 'causing' it. Herodotus uses these two words 91 times in his *Histories*: he was clearly looking for reasons behind historical facts. Hippocratic authors, such as that of *De arte* (late fifth century, ed. Jouanna et al.), are also looking for causes of diseases.[17]

Indeed, in the fifth century more convincing examples of scientific insights are found. Among the philosophers, traces of lasting scientific advances can be

15 But Cornford cannot be followed when he wants to trace those φυσιολόγοι as going back behind a postulated development of Olympic divinities, who hold sway over one province of being each, to a more 'primitive' and mystic-holistic point of view with a non-personal divinity, Φύσις.
16 As Lloyd (1970: 15) points out. But the same is true for the Upanishadic sages, who would not qualify as 'scientists'.
17 e.g. *De arte* 11.4, ed. Jouanna, p. 238: τὸ εἰδέναι τῶν νούσων τὰ αἴτια ('to know the causes of diseases').

found in Parmenides (ca. 540–ca. 480) and Anaxagoras (ca. 499–428). Aristotle seems to agree with our view when he makes natural philosophy begin with these two men.[18] Parmenides had his own school at Velia (south of Naples); a bust of him from around 100 BC was found there, hinting that his memory was still held high then, apparently as a kind of priestly physician (see fig. 8).[19] He wrote a poem in hexameters treating the true nature of being in its first part, and the opinions of men in the second. Only fragments, mostly from the first part, survive. Parmenides is sometimes referred to as the father of logic, although this will also be a back-projection from later times, as his aims would seem to have been at least as much of a metaphysical or mystical kind than of a logical one – if he would have agreed at all to separate reality into such compartments. But it must not be forgotten that the second, apparently much longer, part of his poem dealt with the 'opinions of mortals, which cannot be truly trusted',[20] which were apparently in their time an advanced scientifically based *Weltanschauung* that included novel discoveries, for instance in astronomy that 'the moon gets its light from the sun, the earth is spherical, and the morning star is identical to the evening star'.[21] Besides inductive science, deduction is also well developed in Parmenides, who offers the first attested case of a deductive chain leading from an axiomatic 'it is' to a number of attributes of being:[22] it is eternal (ἀγένητον ἀνώλεθρον; 8.3, ed. Coxon = D8 LM = B8 DK), one of its kind (μουνογενές; 8.4), indivisible (οὐδὲ διαιρετόν 8,22), continuous (ξυνεχές; 8.25), timeless (ἄναρχον ἄπαυστον; 8.27), all of this of necessity (ἀνάγκη πείρατος ἐν δεσμοῖσιν ἔχει; 8.30–31), it is like a round sphere (εὐκύκλου σφαίρης ἐναλίγκιον ὄγκῳ; 8.43). Lloyd sees dialectical argumentation well developed for the first time here. Indeed, in the 148 extant lines of Parmenides (frags 1–17) there are many logical particles – γάρ (31), ἐπεί (9) – and 70 occurrences of the verb εἶναι. Parmenides writes in hexameters, thus in a language based on epic, Homeric poetry.[23] In contrast, the first 148 lines of the *Odyssey* contain γάρ (6),

18 If we understand the hint in his lost *Protrepticus* (frag. 52 Rose = Iamblichus, *De communi mathematica scientia*, ed. Festa & Klein, p. 79) correctly; see the edition by Hutchinson & Johnson, p. 17.
19 See Burkert (1969b: 22) on Οὐλιάδης.
20 Frag. 1.30, ed. Coxon = D4.30 LM = B1.30 DK: βροτῶν δόξας, τῇς οὐκ ἔνι πίστις ἀληθής.
21 Graham (2013: 230). Cf. frag. 9 Coxon as a summary; frags 14–15 Coxon about the Moon's light; frag. 12 Coxon about five climate zones on a round Earth, explained more fully by Aetius (II.7) in test. 61 Coxon.
22 Similarly Lloyd (1979: 69–70). According to Lloyd (265), it is with Parmenides and Heraclitus that epistemological questions are first raised.
23 Its indebtedness to Homeric epic is clearly demonstrated in the introduction to Coxon's edition.

ἐπεί (2), and εἶναι (8) much less often.[24] Anaxagoras developed much of this further, and among other things learned to understand the nature of solar and lunar eclipses, that is, that they are caused by the Sun's light being blocked (although he did not accept the Parmenidean round Earth). After him this view quickly became *communis opinio*.[25] Anaxagoras changed the written medium and wrote his book in prose, of which again only fragments remain. Besides astronomical questions, it treated much of the physical world, especially noteworthy phenomena (much like Seneca's *Naturales quaestiones* was to do; see chap. 8 §8).

Fig. 8: Bust of Parmenides from his hometown of Velia, including the inscription Παρμενίδης Πύρητος Οὐλιάδης φυσικός.
Source: https://commons.wikimedia.org/wiki/File:Busto_di_Parmenide.jpg (image by user Sergio Spolti, https://creativecommons.org/licenses/by-sa/4.0; modified).

24 Other particles like δέ (42 and 49) or καί (38 and 22) exhibit more similar numbers.
25 See Graham (2013: 216).

Besides astronomy, geometry also seems to have developed into a scientific branch in the fifth century. Unfortunately, we are even less well informed about these beginnings. Geometry is in many respects an especially important science, as it was to become paradigmatic and its methods were copied within other sciences until at least early modern times (see §7). The important discoveries by Hippocrates of Chios (ca. 470–ca. 410), Theaetetus of Athens (ca. 417–368), and others culminate in the great work of Euclid (ca. 325–ca. 270).[26] Its title, στοιχεῖα 'arguments set in line'[27] (see chap. 3 §11 above), exemplifies its scientific nature; this work and its translations will be discussed in chapter 22.

Democritus of Abdera (ca. 460–ca. 370), who already belongs to the generation of Socrates, seems to be consciously engaged in shaping language to contain his thinking. Unfortunately, there are only some three hundred, mostly short fragments left of his numerous treatises.[28] The LSJ dictionary lists 628 lemmata in which Democritus is mentioned, of which slightly more than one hundred are otherwise practically not or not at all used by any other Greek writer. A few examples follow.[29] δέν (as an opposite to μηδέν 'nothing') denoted his atoms. This linguistically misconstructed word (μηδέν < μηδ' ἕν) was long thought to have been Democritus' invention, but now another instance of it has become known.[30] The word στοιχεῖα, adapted from its original meaning, 'letters', denotes for Democritus the atoms which make up things in a similar way to how letters make up words. Here are some words that are only known from him (translations from LSJ):

- ἀθαμβίη ('imperturbability'; D322 LM = B215 DK),
- ἀπανδόκευτος ('without an inn to rest'; D292 LM = B230 DK),
- διαθιγή ('mutual contact'; R47 LM = A38 DK),
- ἐγκαταβυσσόομαι ('penetrate deeply'; D152 LM = A77 DK),
- ἰθύτρην ('bored straight'; R3e LM = B128 DK),
- ὀλιγομυθίη ('speaking little'; D329 LM = B274 DK),
- πυκνάρμων ('close-fitted'; D117 LM = A93 DK),

26 The old mathematicians' works have nearly completely perished, as they were eclipsed by Euclid's *Elementa*. The above information stems from Proclus, *In Euclidem* 66–67, ed. Friedlein. It is discussed in Lloyd (1979: 108–115).

27 Burkert (1972: 402).

28 It is usually not possible to tell Democritus apart from his teacher Leucippus in the surviving fragments. 'Democritus' is therefore used to cover either of these two philosophers. DK has 298 fragments termed 'genuine'; as Laks & Most do not differentiate fragments and testimonies, counting them is more difficult, but the number will not have increased greatly.

29 See von Fritz (1938).

30 See Burkert (1997: 32–33).

- τενθρηνιῶδες ('honeycombed'; D192 LM = A155 DK),
- φυσιοποιέω ('remould as by a second nature'; D403 LM = B33 DK) and the lists in R3 and R4 LM.[31]

Many of these words are compounds reminiscent of epic poetry. Against expectations, many of them are not nouns (although abstracta in -ία are also common); more frequently, they are adjectives (often in -ής) or verbs (often in -έω or -όω). Of course, Democritus also uses normal words technically, such as τροπή ('position') or ῥυσμός ('shape').[32] Such a linguistic approach, which easily coins new expressions for novel thought, stands in stark contrast to Plato (who did not coin any new words) and Aristotle (who did so, but rarely and quite differently). This approach to coining new terms is examined below (chap. 21).

In short, this evidence shows that while traces of scientific activities in the sixth century are meagre at best, things change significantly in the fifth. In addition to astronomy and demonstrative mathematics, this trend can be seen confirmed in Hippocratic medicine, apparently initiated by Hippocrates of Cos (fl. ca. 430).[33] Among Hippocratic physicians, a new methodological approach can, for instance, be seen in the author of *De morbo sacro* (ed. Jouanna), who tries to find natural causes, that is, causes from within φύσις, which follows its own rules (no intervention by divinities), to explain epilepsy, a disease that was especially prone to be linked with the divine. Unfortunately his 'natural' explanations seem to us today just as fanciful as those given by his opponents, the temple healers: he believed that the veins carrying air and phlegm to the brain do not work properly. Although his reasoning does make use of causes, these are fanciful and untested claims and do not at all correspond to observable facts. Accordingly, his remedies against epilepsy (mostly dietetic) are likely to have had as much (or as little) effect as those of the temple healers. Nonetheless, his approach was more scientific, although for the layman the difference between the two ways of healing may not have been obvious.[34] Some of these Hippocratic authors recorded not only their successes but also their failures in a scientific spirit, so that others could learn from them: 'a quite unprecedented phenomenon' (Lloyd 1987: 124). It would cer-

31 Some of the words from LSJ are no longer found in the new edition by Laks & Most, such as ἀγαθοφανής ('appearing good'; Stobaeus III.29.67 = B82 DK, compare D351 LM).

32 Aristotle explains them: ῥυσμὸς σχῆμά ἐστιν ἡ δὲ διαθιγὴ τάξις ἡ δὲ τροπὴ θέσις ('ῥυσμός is their [the atoms'] shape, διαθιγή the disposition, τροπή the position'; *Metaphysica* A4, 985b16–17).

33 Burkert (1972: 402), with references.

34 In fact, this difference between scientific medicine and other kinds of healing is often still unclear to the layman today.

tainly be rewarding to study the Hippocratic authors' language further. The logical nexuses are strongly emphasised by some of them, for example by linking statements with γάρ.[35]

Other scientific fields, such as historiography and geography, developed in a similar critical spirit during the fifth century. Hecataeus of Miletus (ca. 550–ca. 480) is said to have designed the first world map, and Herodotus of Halicarnassus (ca. 485–424) writes his *Historiae* in a spirit of trying to see events causally connected to one another. These later developments were already happening during the rise of sophistic rhetoric, pointing the way to Plato and his pupil Aristotle. The innovations in this period in natural philosophy, medicine, and history may well be addressed as a new Greek *Denkstil;* this *Denkstil* would entail a new, critical appraisal of the rôle of language. This became important among the sophists.

§3 How the term σοφιστής changed its meaning from 'expert' to 'sophist' – i.e. someone who takes money for teaching how to persuade people, regardless of the truth of the position – can be followed nicely in Laks & Most (vol. 8, chap. 42). The sophists[36] were certainly 'no self-contained group, let alone one that constituted itself self-consciously as a movement or school' (Lloyd 1987: 93). But this loose group of teachers can be said to be the inventors of higher education.[37] What unites them is an interest in rhetoric and dialectic, a demand in Greek society for more than elementary education, the development of scientific subjects, a growing interest in political and moral questions.[38] The realisation of the power and ambiguity of words was also very important in forming a consciousness of how convincing others – and at a later stage also oneself – can be achieved.

In historiography, sophist influence is patent in Thucydides (ca. 460–ca. 400), who tries to be 'scientific' by stressing the amount of certainty, τὸ σαφές. He uses this word 34 times. If personal observation was impossible, τεκμήρια ('sure signs or tokens, proofs') were used; the same usage of these words occurs in some of the Hippocratic texts.[39] When, especially for times long past, τεκμήρια were

35 As observed by Lloyd (1987: 123) for *De aeribus aquis locis.*
36 Guthrie (1971: 204–219); von Fritz (1971: 223–227).
37 Burkert (2008: 58): 'it was the sophists who invented higher education as a new form of class distinction.'
38 See Lloyd (1987: 93).
39 e.g. *De arte* 5.3, ed. Jouanna et al., p. 228: Καὶ τοῦτό γε τεκμήριον μέγα τῇ οὐσίῃ τῆς τέχνης, ὅτι ἐοῦσά τέ ἐστι καὶ μεγάλη, ὅπου γε φαίνονται καὶ οἱ μὴ νομίζοντες αὐτὴν εἶναι, σῳζόμενοι δι' αὐτήν ('This too is a great sign of the strength of the [medical] art proving its existence and greatness, that also those who do not believe in its existence can be healed by it').

also unavailable, only τὸ εἰκός (‘probability’) remained (as later for Aristotle).[40] In chapters 20–22, Thucydides speaks about the methods and goals of his history. An example (*Historiae* I.22.3–4, ed. Jones):

> ἐπιπόνως δὲ ηὑρίσκετο, διότι οἱ παρόντες τοῖς ἔργοις ἑκάστοις οὐ ταὐτὰ περὶ τῶν αὐτῶν ἔλεγον, ἀλλ’ ὡς ἑκατέρων τις εὐνοίας ἢ μνήμης ἔχοι. καὶ ἐς μὲν ἀκρόασιν ἴσως τὸ μὴ μυθῶδες αὐτῶν ἀτερπέστερον φανεῖται· ὅσοι δὲ βουλήσονται τῶν τε γενομένων τὸ σαφὲς σκοπεῖν καὶ τῶν μελλόντων ποτὲ αὖθις κατὰ τὸ ἀνθρώπινον τοιούτων καὶ παραπλησίων ἔσεσθαι, ὠφέλιμα κρίνειν αὐτὰ ἀρκούντως ἕξει. κτῆμά τε ἐς αἰεὶ μᾶλλον ἢ ἀγώνισμα ἐς τὸ παραχρῆμα ἀκούειν ξύγκειται.
> ‘[What happened] was discovered laboriously, for those present at the respective events did not report the same about the same things, but instead as goodwill and memory of each had it. The fact that the book lacks myth may render it less enjoyable for hearing, but to those who will wish to spot what is certain about past deeds, which according to human nature will be the same or similar again, it will be sufficiently useful. It is composed as a possession for all times rather than to hear applause in the present.’

Such a way of thinking is hardly imaginable without the sophist movement, but in contrast to it, Thucydides points out, he sets out to approach what actually happened as truthfully as possible, not to use the εἰκός merely in order to reach his own personal goals. As discussed above (chap. 3 §5), this may warrant speaking of scientific historiography. Laks & Most offer good reasons (vol. 8, pp. 293–294) for including his contemporary Socrates (ca. 470–399) among the sophists. He did not commend his philosophy to writing, but his pupils Plato and (indirectly) Aristotle will be central for what follows. Both had their own private schools that continued to work long after their founders’ death.[41]

Plato and his Academy

§4 Judging from his extant works, Plato’s (mid 420s–348/347) interest in the natural sciences was rather limited. They do not figure in his utopian *Republic*, and indeed, only one of his many extant exoteric works, the *Timaeus*, is concerned with them. But to what extent scientific study was an integral part of his school, the Academy, and of his unwritten teaching is a much-debated question.[42] Philosophy, rhetoric, and moral and political theory seem to have been central in the

40 See Lesky (1993: 517).
41 This may also have been the case with some of the ‘pre-Socratics’, especially Pythagoras and Parmenides, as well as Heraclitus through the Stoics – but it is less well documented and their influence was much less lasting.
42 For instance, Gaiser speaks of a ‘Begründung der Wissenschaft in der platonischen Schule’ (‘foundation of science at Plato’s school’; 1963: 14).

Academy, but famous geometers such as Eudoxus of Cnidus also frequented it, and Plato's high esteem for mathematics becomes evident enough from the board at his school's entrance:

> ἀγεωμέτρητος μηδεὶς εἰσίτω.[43]
> 'No one who knows no geometry shall enter.'

First, some key passages in Plato's preserved, exoteric works are considered, and then a few words will be said about his handling of language. In the *Timaeus*, he attempts to present at least an εἰκὸς μῦθος (28d) of how nature works, a true λόγος being impossible for non-necessary, non-ideal things (e.g. 27d, 29b). This unusual work will be the only one known directly in the Latin Middle Ages. In this dialogue, Plato uses mathematics (e.g. the five Platonic bodies) to explain the constituents of matter in a very speculative way;[44] apparently, he reworks a lot of physical and biological theories from his predecessors. It is usually hardly possible to determine what is his own contribution and what comes from them, but Lloyd (1968: 88–89) argues that at least some of it is indeed his own. Lloyd is rather sceptical of the scientific character of the work and of Plato's approach in general,[45] but concedes that the greatest legacy of Plato to natural science may have been his 'general belief in the mathematical structure of the universe and his ideal of the mathematical framework of scientific explanations' (91).

As discussed above (chap. 2 §2), Plato discusses in his *Theaetetus* what ἐπιστήμη is, here still taken *sensu lato*, as true 'knowledge' in general. The dialogue's results are mostly negative, but it does contain some key future terms. Plato shows that knowledge does not come from the senses and that there are difficulties in defining it as correct opinion (ἀληθὴς δόξα, 187b), so this definition is improved by adding μετὰ λόγου (201c–d), concluding (202c2–3):

> τὸν γὰρ μὴ δυνάμενον δοῦναί τε καὶ δέξασθαι λόγον ἀνεπιστήμονα εἶναι περὶ τούτου.
> 'for someone who cannot give or accept an account is without knowledge about it [the thing under discussion].'[46]

43 Preserved e.g. by Ps-Galen, *De partibus philosophiae* 2, ed. Kotre.
44 See Lloyd (1968: 90), who notes 'his general preference for abstract reasoning rather than observation'.
45 See Lloyd (1968: 92), writing that 'we should rather conclude that at no stage in Plato's life, either during or after the composition of his chief cosmological dialogue, did he consider that what we should call natural science is science in the fullest or highest sense of the term'.
46 The definition is taken up by Aristotle, *Analytica posteriora* II.19, 100b10; see Burnyeat (1981: 136).

From 206c onward, the precise meaning of λόγος is sought, leading to the final attempt at a definition (208e):

> Ὃς δ’ ἂν μετ’ ὀρθῆς δόξης περὶ ὁτουοῦν τῶν ὄντων τὴν διαφορὰν τῶν ἄλλων προσλάβῃ, αὐτοῦ ἐπιστήμων γεγονὼς ἔσται οὗ πρότερον ἦν δοξαστής.
> ‘Someone who adds the ability to distinguish from other things to a right opinion about anything: he will have become knowledgeable about what he previously only held as opinion.’

Knowledge able to distinguish the reason or definition (λόγον [...] λήψῃ; 208d) of something, truly understands it. In the *Euthyphron* (11a), ‘definition’ (in this case of τὸ ὅσιον) is said to be directed at the οὐσία of the *definiendum*. Plato speaks of the ἐκεῖνο ἄνευ οὗ (*sine quo non*) in his *Phaedon* (99a–b) to differentiate between necessary causes and merely concomitant factors. This can be generalised: it is not only causes that reflect a scientific endeavour but also the desire in general to understand a phenomenon out of itself instead of just using it for some end or accepting opinions about it. Thus, mathematics can be said to arise when proofs are sought for claims, an approach that produced Euclid’s *Elementa*. It is especially Plato who distinguishes strictly between the provably true and the merely probable, which latter must remain in the confines of mere δόξα and is thus – according to Plato – not susceptible to scientific study. Hence, his philosophy is hardly interested in ‘physical’ things treated by the natural sciences (excepting the *Timaeus*). In his *Philebus*, Plato marks clarity, exactness, and truth as the distinguishing characteristics of philosophical dialectics, in contrast to mere persuasion (58b–c):

> οὐκ, ὦ φίλε Πρώταρχε, τοῦτο ἔγωγε ἐζήτουν πω, τίς τέχνη ἢ τίς ἐπιστήμη πασῶν διαφέρει τῷ μεγίστη καὶ ἀρίστη καὶ πλεῖστα ὠφελοῦσα ἡμᾶς, ἀλλὰ τίς ποτε τὸ σαφὲς καὶ τἀκριβὲς καὶ τὸ ἀληθέστατον.
> ‘I have not, friend Protarchus, just been seeking what kind of art or knowledge of all of them is distinguished as the greatest, best, and of most use to us, but what is the one that is most certain, exact and truthful.’

Besides these passages from his works for a broad public, one wonders what he stated in his esoteric works and possibly in his unwritten teachings. Already in Antiquity, there was a vivid discussion about the latter. The neo-Platonists with their hierarchical worldview, in which mathematics plays an important rôle alongside the Platonic ideas high up in the hierarchy, saw themselves as faithful pupils of Plato. Gaiser (1963: appendix) presents a collection of all the passages from Antiquity that mention Plato’s unwritten teaching, and is able to deduce some basic characteristics from it. He sees the roots of science as we know it today more in Plato than in Aristotle. But this seems questionable: later chapters will make clear that these two approaches were both important for the development of science, but that Aristotle's more open and observational, less 'metaphysical' approach was of greater importance for acquiring new scientific understanding. Nonetheless, Gaiser is certainly right when he states: 'Platon hat, geschichtlich gesehen, zu der heute erreichten Mathematisierung der Natur den entscheidenden Anstoß gegeben' ('From a historical point of view, Plato gave the decisive impetus for the mathematisation of nature achieved today'; 1963: 38).

Besides his emphasis on the mathematical structure of reality, Plato's most important other contribution to the advancement of science will have to be seen in his strict and conscious employment of language, in which he was trained by the sophists' eristic use of it. Plato's view of the limits of language is expressed in the *Cratylus*. Socrates discusses with the Heraclitean Cratylus about whether (383a)

> ὀνόματος ὀρθότητα εἶναι ἑκάστῳ τῶν ὄντων φύσει πεφυκυῖαν,
> 'the correctness of names is given by nature to each thing',

which Socrates attempts to refute. But the discussion remains on a terminological level; the wider question of the relation between statements and facts is – among the surviving texts – only really tackled by Aristotle's logic. Plato's practical approach to language can be studied better. He does not seem to coin any new words in his surviving texts at all;[47] instead, he uses common words in specialised senses, such as εἶδος, ἰδέα, οὐσία, ἀρχή. But it is with Plato that we can observe for the first time (in extant literature) philosophical concepts being formed into systems of terms that receive their precise meaning within the system.[48] Examples collected by Eucken (1879) for such technical terminology contain many words of lasting influence, such as ἀναλογία, αἰσθητός–νοητός, γένεσις–οὐσία, εἰκός. But Plato tended to use several synonyms for some of his key concepts, as Diogenes Laertius (*De vita philosophorum* III.64, ed. Long, vol. 1, p. 147) already criticised:

> πολλάκις δὲ καὶ διαφέρουσιν ὀνόμασιν ἐπὶ τοῦ αὐτοῦ σημαινομένου χρῆται. τὴν γοῦν ἰδέαν καὶ εἶδος ὀνομάζει καὶ γένος καὶ παράδειγμα καὶ ἀρχὴν καὶ αἴτιον.
> 'Often he uses different words for the same concept. Indeed, he calls the "idea" also "form" and "genus" and "paradigm" and "principle" and "cause".'

There is a less obvious point in which Plato proved to be very important for the development of science: his 'most trivial, "philosophical" view that spheres are "di-

47 Von Fritz (1938: 64; on the following words, see 52–61).

48 See Eucken, who speaks of 'das erste umfassende Begriffssystem [...]. Es bilden sich Gruppen und Reihen' ('the first comprehensive system of notions [...]. Groups and series are formed'; 1879: 17).

vinely" or "transcendentally" beautiful' (Bochner 1969: 95). As von Fritz[49] points out, this a priori aesthetic point of view was to stimulate the development of astronomy in a way that the more mechanistic but non-quantitative vortex theory of Democritus never could have. Plato's predilection for mathematics and for its beauty stimulated scientific research at his own school: Eudoxus of Cnidos developed the epicycle theory, probably on Plato's instigation (as von Fritz showed). His school, the Academy, was home to many important scientific advances; not least, it was the environment where Aristotle's mind was formed.[50] Among Plato's pupils, it was not only Aristotle who developed his approaches further: for instance, Speusippus seems to have studied the relationship between words and entities in the world, coining terms such as ταὐτώνυμα (ὁμώνυμα, συνώνυμα) vs ἑτερώνυμα (ἰδίως ἑτερώνυμα, πολυώνυμα, παρώνυμα).[51] Much of this system is taken over by Aristotle. Plato's Academy continued to function as a philosophical and scientific school until Sulla destroyed it during the Romans' conquest of Athens (86 BC). In Christian times, a new Academy existed in Athens that claimed to have a continuous list of heads of school since Plato, but in the half-millennium in between, nothing is heard of it.

Vlastos (1975: 82–94) points out that Plato's 'a priori' theories did take into account known 'hard facts' (e.g. by then, the sphericity of the Earth) if they were well established. Plato's 'naturalistic scenario' (97) leads to important theoretical advances. In the case of 'chemistry', however, his ingenious (although completely untestable) theory of matter being made up of triangles and squares does not have this effect – at least in Antiquity.[52] It would seem that this is so because in chemistry the 'hard facts' were in his time basically everyday knowledge only. It may well be that Aristotle was aware of the lack of 'hard facts' in many fields and that this may have prompted him to start looking for and collecting new ones which could be used to build fanciful theories (something Aristotle enjoys hardly less than his teacher).

49 Von Fritz (1938: 180); this view is shared by Vlastos (1975: 63).

50 'Auch hat Plato die Einzelwissenschaften in der Akademie auf den verschiedensten Gebieten gefördert. Aber erst Aristoteles hat sie als Wissenschaften in systematischer Verankerung insgesamt etabliert' ('Plato also promoted the individual sciences at his Academy in a wide variety of fields. But it was Aristotle who first established them properly as sciences in a systematic embedding'; Flashar 2013: 368).

51 From frag. 32a Lang; see the study by Heitsch (1972).

52 Plato would certainly be delighted by modern organic chemistry, where geometric arrangements of atoms, such as the hexagon in benzene, are crucial.

Aristotle and the Peripatos

> In seiner Philosophie ist Aristoteles der zur höchsten Kunst des methodischen Denkens gesteigerte Ausdruck der weltanschaulichen Problematik seiner Zeit. In seiner einzelwissenschaftlichen Forscherarbeit dagegen ist er mehr, hier wächst er weit über seine Umwelt hinaus.
> 'In his philosophy, Aristotle represents the expression of the problems of the worldview of his time, elevated to the highest art of methodical thinking. In his individual scientific research work, however, he is more: here he grows far beyond his environment.'
> Jaeger (1955: 428)

§5 Aristotle,[53] like Plato, published works and taught lectures both for a wider audience (ἐξωτερικά) and for the advanced, few pupils (ἀκροατικά).[54] The Aristotelian texts that survive today belong to the latter group; they can be seen as lecture notes in varying degrees of stylistic revision. In them, we see Aristotle trying to understand all the domains of the world around and within him with a scientific spirit aptly called by Wehrli 'umfassende Daseinserforschung' ('comprehensive exploration of existence'; 1944–1978: 10:100); the main concern of his approach to philosophy was clearly science – in contrast to Plato, for whom the ethical development of man seems to have been of greater importance. Due to Aristotle's lasting importance in scientific methodology, his use of language in science and his scientific approach are now considered in some more detail.[55] Aristotle's striking new scientific approach led some to coin the verb ἀριστοτελίζειν.[56]

Where Aristotle's scientific methodology is concerned, there is a significant difference between his theoretical writings about the scientific method and how he actually worked as a scientist, for instance in biology.[57] The theoretical writings describe an apodictic, deductive character of science and strive for complete certainty, as detailed in the *Organon* and especially the *Analytica posteriora*. The aim of his work in practice can be described as 'scharfsinnige Strukturanalyse'

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53 Still fundamental on Aristotle's oeuvre and methodology: Düring (1966). On his scientific method, see Kullmann (1974, 1998).

54 These terms are found in Aulus Gellius, *Noctes Atticae* XX.5.1, ed. Marache, vol. 1, p. 159: *Alia erant, quae nominabat ἐξωτερικά, alia, quae appellabat ἀκροατικά* ('There were some he called exoteric, some he called lecture notes').

55 For a condensed summary of the transmission of Aristotle's works in the Middle Ages, see Roelli (2020b).

56 Strabo, *Geographica* XIII.1.54, ed. Radt, vol. 3, p. 602: φιλοσοφεῖν καὶ ἀριστοτελίζειν ('to philosophise and Aristotelianise').

57 This was pointed out by Düring (1966: 21–22).

('astute structural analysis'; Düring 1966: 22) of a much more inductive character using methods that seem appropriate for the problem at hand. Lloyd wonders how Aristotle's important insight that scientific knowledge can hold good not only always, but also 'always or for the most part', can be squared with the formal, logical approach in the *Analytica posteriora*.[58] The mathematical foundations for stochastics able to deal with such cases were, of course, not anywhere in sight. Lloyd (1987: 141–143) reaches the conclusion that Aristotle presents a pedagogic model of demonstration, a mere ideal, in the *Analytica posteriora*.[59] Aristotle's actual practical approach is to begin with a collection of material (including earlier writers' opinions), then he tackles the question of why the material is the way it is, and then he tries to establish the characteristic structures in it synthetically (Düring 1966: 23). In this manner, he studied a wide range of phenomena scientifically, each with a methodology that seemed appropriate to it. Thus, Aristotle describes in the *Organon* one kind of science applicable to mathematics (and to some extent to what will be called the *quadrivium*), but employs a rather different one when the topic does not seem amenable to it, for instance in his zoology. Both these paths will find imitators over the centuries, and the discussion whether there can be 'real' science about uncertain, transient things – a central question in Plato's Academy – is kept alive. Deniers are, although under somewhat different circumstances and possibly more radically, still present today in the form of scholars such as Feyerabend (mentioned in chap. 4 §1 above).

Above (chap. 2 §1), it was seen that in Aristotle the term ἐπιστήμη is often used to denote a special kind of 'knowledge', a 'scientific' one that can be divided into separate fields and that is based on structural understanding.[60] In fact, the word is often found in the plural ἐπιστῆμαι, and Aristotle held that each science ought to be based on its own principles, thus establishing the concept of demarcated scientific disciplines. Although this step was very important for the development of the sciences, it also had questionable consequences, for instance when Aristotle refrained from using mathematics in the physical sciences. If it is accepted that the approach in the *Analytica posteriora* was, for Aristotle, not meant to be generally applicable to all sciences, we can look for descriptions of what ἐπιστήμη is for him in his practical scientific works. He seems to be continually

58 e.g. *Physica* II.5, 196b10–11: τὰ μὲν ἀεὶ ὡσαύτως γιγνόμενα τὰ δὲ ὡς ἐπὶ τὸ πολύ ('some always happen the same way, some most of the time'). ἐπὶ τὸ πολύ is a very common phrase in Aristotle: 260 occurrences in Corpus Corporum. Mignucci (1981) studies some logical implications of using statements that are true only ἐπὶ τὸ πολύ.

59 The problem is also discussed by Wieland (1970: 20), whose conclusion is that Aristotle lacked a comprehensive system.

60 Burnyeat (1981: 129) speaks of 'knowledge with full understanding'.

looking for and remoulding its core meaning in these works. For Aristotle ἐπιστῆμαι are a *species* (εἶδος) of ὑπόληψις (‘a way of acquiring knowledge’). Other such species are δόξα (‘opinion’) and φρόνησις (‘prudence’, i.e. ‘practical wisdom; *De anima* III.3 427b10). The opposite of ἐπιστήμη when taken *sensu stricto* is δόξα; when meaning ‘knowledge’ in general, it is ἄγνοια (‘ignorance, the lack of knowledge’; *Topica* VIII.1, 156b12). In his *Ethica Nicomachea*, ἐπιστήμη is an ‘intellectual virtue’ (διανοητικὴ ἀρετή; II.1, 1103a6); there Aristotle distinguishes two kinds of ‘virtues’:[61] ethical ones and ‘intellectual’ ones – more precisely, those concerned with thinking or deliberating. Among these virtues, there are five species ‘in which someone can be truthful by affirming or negating’ (οἷς ἀληθεύει ἡ ψυχὴ τῷ καταφάναι ἢ ἀποφάναι): τέχνη, ἐπιστήμη, φρόνησις, σοφία, and νοῦς; there are others that do not preclude being wrong, such as ὑπόληψις in general and δόξα (VI.3, 1139b15–17). These terms were studied above (chap. 3); they tend to be hard to translate into other languages and epochs. Only to some extent do they fit ‘practically minded craft’, ‘scientific knowledge’, ‘practical wisdom’, ‘speculative wisdom’, and ‘intuitive grasping’ respectively.[62]

On the ‘input’ side, ἐπιστῆμαι are based on the senses (αἴσθησις; *Analytica posteriora* I.18, 81a38–39), but there are also ἐπιστῆμαι μαθηματικαί for which this does not seem to hold (*Metaphysica* M4, 1078b7–17). They tend to be a generalised form of experience, but unlike it they are teachable:

> γίγνεται δὲ τέχνη ὅταν ἐκ πολλῶν τῆς ἐμπειρίας ἐννοημάτων μία καθόλου γένηται περὶ τῶν ὁμοίων ὑπόληψις. [...] ὅλως τε σημεῖον τοῦ εἰδότος καὶ μὴ εἰδότος τὸ δύνασθαι διδάσκειν ἐστίν, καὶ διὰ τοῦτο τὴν τέχνην τῆς ἐμπειρίας ἡγούμεθα μᾶλλον ἐπιστήμην εἶναι. (*Metaphysica* A1, 981a5–7, 981b7–9)
> ‘An art [τέχνη] arises when from many concepts taken from experience one general way of acquiring knowledge from similar cases arises. [...] The ability to teach something is clearly a sign of knowing or not knowing it; because of this, we take art [τέχνη] to be scientific knowledge to a higher degree than mere experience.’
> ἔτι διδακτὴ ἅπασα ἐπιστήμη δοκεῖ εἶναι, καὶ τὸ ἐπιστητὸν μαθητόν. (*Ethica Nicomachea* VI.3, 1139b)
> ‘Further, all science seems to be teachable, and scientific knowledge learnable.’

It seems that for Aristotle there is a progression from mere experience to ἐπιστήμη, with τέχνη wavering in between; apparently there are higher, more ‘understanding’ arts and lower, more merely practical ones. The former are described in *Metaphysica* A1, 981a28–30:

61 The translation of ἀρετή as ‘virtue’ is problematic. The scope of the Greek word is wider; it means quite generally the best possible state of something.
62 See further Flashar (2013: 88–91).

τοῦτο δ’ ὅτι οἱ μὲν [i.e. οἱ τεχνίται] τὴν αἰτίαν ἴσασιν οἱ δ’ [i.e. οἱ ἔμπειροι] οὔ. οἱ μὲν γὰρ ἔμπειροι τὸ ὅτι μὲν ἴσασι, διότι δ’ οὐκ ἴσασιν· οἱ δὲ τὸ διότι[63] καὶ τὴν αἰτίαν γνωρίζουσιν.
‘This is so because the former [practical scientists] know the reasons, the latter [mere craftsmen] do not. For craftsmen know the “that” but do not know the “because”; the former also get to know the “because” and the reason.’

Such knowing the reasons or causes is typical of scientific understanding, as he points out a little later (*Metaphysica* A3, 983a24–26):

Ἐπεὶ δὲ φανερὸν ὅτι τῶν ἐξ ἀρχῆς αἰτίων δεῖ λαβεῖν ἐπιστήμην (τότε γὰρ εἰδέναι φαμὲν ἕκαστον, ὅταν τὴν πρώτην αἰτίαν οἰώμεθα γνωρίζειν), [...]
As it is obvious that one has to reach scientific knowledge from reasoned principles (for we claim to know something when we believe to have acquired knowledge of the first reason), [...] [Aristotle’s famous four causes follow].’

The importance of causes has become a necessary part of science, at least until recently.[64] It is still present in the proposed criteria for science, although in a somewhat more general way, in criterion II, which strives for step-by-step ‘mechanisms’: science must still show the ‘because’ (τὸ διότι), not only the ‘that’ (τὸ ὅτι). But ἐπιστῆμαι do study both facts and their reasons; they may be more descriptive or explanatory. They are about general[65] and measurable[66] things. Seen from the other side – not that of their object but of the scientist – they are based on fitting definitions.[67] From these arise λόγοι (‘conclusions’) that find ἀρχαί (‘principles’) and αἰτίαι (‘reasons/causes’) with which one can understand the real being of what is under consideration, ‘that which it was’ (τὸ τί ἦν εἶναι). This mental process happens within νοῦς (‘the intuitively grasping “intellect”’).[68] Aristotle etymologises the word ἐπιστήμη as making the scientist’s soul stand still, being unable to think or perceive well in chaos,[69] so the word was felt to belong to the

63 Similarly in *Analytica posteriora* I.13, 78a22.
64 In the twentieth century, this concept becomes rather blurred by advances in mathematics and quantum physics, at least in some fields.
65 *Ethica Nicomachea* X.10, 1180b15: τοῦ κοινοῦ γὰρ αἱ ἐπιστῆμαι (‘The sciences are of what is common’).
66 *Metaphysica* I6, 1057a11–12: τρόπον τινὰ ἡ ἐπιστήμη μετρεῖται τῷ ἐπιστητῷ (‘In a certain sense, science is measured by what is scientifically knowable’).
67 *Analytica posteriora* II.17, 99a22–23: πᾶσαι αἱ ἐπιστῆμαι δι’ ὁρισμοῦ γίγνονται (‘All sciences arise from defining’).
68 *Analytica posteriora* II.19, 100b14–15: εἰ οὖν μηδὲν ἄλλο παρ’ ἐπιστήμην γένος ἔχομεν ἀληθές, νοῦς ἂν εἴη ἐπιστήμης ἀρχή (‘If we dispose of no other faculty for the true except science, the intuitive intellect [νοῦς] must be the source of science’).
69 *Problemata* 30, 956b40–957a2: ἐπιστήμη ὅτι τὴν ψυχὴν ἵστησιν, κινουμένης γὰρ καὶ φερομένης οὔτε αἰσθέσθαι οὔτε διανοηθῆναι δυνατόν (‘“Science” [is called thus] because it makes the

kinship of ἵστημι (see chap. 2 §1 above); similarly, English 'to under-stand' and German *ver-stehen*. Something is understood when one has grasped its necessity, the fact that it cannot be different (*Analytica posteriora* I.2, 71b9–12):

> Ἐπίστασθαι δὲ οἰόμεθ' ἕκαστον ἁπλῶς, ἀλλὰ μὴ τὸν σοφιστικὸν τρόπον τὸν κατὰ συμβεβηκός, ὅταν τήν τ' αἰτίαν οἰώμεθα γινώσκειν δι' ἣν τὸ πρᾶγμά ἐστιν, ὅτι ἐκείνου αἰτία ἐστί, καὶ μὴ ἐνδέχεσθαι τοῦτ' ἄλλως ἔχειν.
> 'We believe to have understood something simply (that is, not – as the sophists do – by means of accidentals) when we believe to have known the cause through which the thing is, that is, the cause of it, and that it cannot be different.'

Possibly even more important than Aristotle's emphasis on causation are logical rules that allow logically sound conclusions to be separated from ones that are merely able to persuade but lack logical rigour. The sophists' way of aiming purely at persuasion made Plato and his pupils aware of this problem. Aristotle formulated clear laws for what may be taken to be a logically sound conclusion from known facts and what may not. His basic writing on this subject, the *Organon*, will be of foremost importance in the re-emergence of his scientific spirit in the Latin Middle Ages. Aristotle himself seems aware that he had to start almost from scratch in developing logical foundations for science and philosophy (*De sophisticis elenchis* 33, 184a9–b8; the treatise's very end):

> καὶ περὶ μὲν τῶν ῥητορικῶν ὑπῆρχε πολλὰ καὶ παλαιὰ τὰ λεγόμενα, περὶ δὲ τοῦ συλλογίζεσθαι παντελῶς οὐδὲν εἴχομεν πρότερον λέγειν ἢ τριβῇ ζητοῦντες πολὺν χρόνον ἐπονοῦμεν. εἰ δὲ φαίνεται θεασαμένοις ὑμῖν, ὡς ἐκ τοιούτων ἐξ ἀρχῆς ὑπαρχόντων, ἔχειν ἡ μέθοδος ἱκανῶς παρὰ τὰς ἄλλας πραγματείας τὰς ἐκ παραδόσεως ηὐξημένας, λοιπὸν ἂν εἴη πάντων ὑμῶν [ἢ] τῶν ἠκροαμένων ἔργον τοῖς μὲν παραλελειμμένοις τῆς μεθόδου συγγνώμην τοῖς δ' εὑρημένοις πολλὴν ἔχειν χάριν.
> 'And teachings about rhetoric have existed in great number and for a long time, but about the way of thinking [logic] we found absolutely nothing to quote, although endeavouring to seek arduously for a long time. But if it should seem to you beholders [of my logic], although beginning from scratch, that the systematic approach is appropriate in comparison with other disciplines which could be augmented from already existing stock, then it should be the duty of all of you listeners to show lenience toward the approach's shortcomings, but great gratitude toward what it has been able to establish.'

As often with Aristotle's statements about predecessors, this cannot be taken fully at face value: it should not be forgotten that questions of method and logic seem to have been discussed in Plato's Academy, as can be gleaned from the titles of

soul stand; the soul is not able to perceive or think when in movement and turmoil'). It is debated whether the *Problemata* are genuine, but at any rate they are a product of Aristotle's school.

some lost works, such as the ὅροι of Speusippus or the τῆς περὶ τὸ διαλέγεσθαι πραγματείας βιβλία, περὶ ἐπιστήμης, and περὶ ἐπιστημοσύνης by Xenocrates.[70] Aristotle's precise rôle can no longer be determined, as these works are completely lost.

Dialectics and rhetoric are for Aristotle faculties (δυνάμεις), thus prerequisites common to all sciences not themselves scientific disciplines.[71] The list of logical fallacies in *De sophisticis elenchis* (4, 165b23–27) indicates what scientific language should avoid:

> Τρόποι δ' εἰσὶ τοῦ μὲν ἐλέγχειν δύο· οἱ μὲν γάρ εἰσι παρὰ τὴν λέξιν, οἱ δ' ἔξω τῆς λέξεως. ἔστι δὲ τὰ μὲν παρὰ τὴν λέξιν ἐμποιοῦντα τὴν φαντασίαν ἓξ τὸν ἀριθμόν· ταῦτα δ' ἐστὶν ὁμωνυμία, ἀμφιβολία, σύνθεσις, διαίρεσις, προσῳδία, σχῆμα λέξεως.
> 'There are two kinds of refutation: one is within language, the other outside of language. The ways of producing illusion within language number six: they are equivocation, ambiguity, combination, division, accent, and form of expression.'

Especially the first two show the importance of an unambiguous vocabulary. This leads us to consider Aristotle's approach to language.[72] Aristotle uses words with the stem of ἐπιστήμ- more than a thousand times, including the lemmata ἀνεπιστημονικός (1), ἀνεπιστημοσύνη (1), ἀνεπιστήμων (6), ἐπιστήμη (980), ἐπιστημονικός (19), ἐπιστημονικῶς (1), ἐπιστημόνως (1), and ἐπιστήμων (55).[73] Strangely, Aristotle does not seem to discuss in any of his many surviving texts how he sees his own highly sophisticated and – as far as we can see – rather idiosyncratic language. He does not address the relation of language and science in general, either. For Aristotle, language is a system of 'symbols' ('what happens to be thrown together with what is symbolised') based on states of the soul; these are the same for all peoples regardless of their language. Similarly, texts are 'symbols' of sounds.[74] The problem of other languages and translatability only starts to be-

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70 A list of their works can be found in Diogenes Laertius, *De vita philosophorum* IV.4–5, 11–14, ed. Long, pp. 165, 169–172.

71 *Rhetorica* I.1, 1354a1–3: ἀμφότεραι γὰρ περὶ τοιούτων τινῶν εἰσιν ἃ κοινὰ τρόπον τινὰ ἁπάντων ἐστὶ γνωρίζειν καὶ οὐδεμιᾶς ἐπιστήμης ἀφωρισμένης ('Both are about such things as are in a certain way common to the cognisance of all men; they are not confined to any [single] science'). See Lloyd (1979: 63).

72 In order to study Aristotle's use of words, the *Index Aristotelicus* by Bonitz is the fundamental tool; the Corpus Corporum and *TLG* search functions are also useful.

73 Data from *TLG* (December 2017).

74 *De interpretatione* 1, 16a3–8: Ἔστι μὲν οὖν τὰ ἐν τῇ φωνῇ τῶν ἐν τῇ ψυχῇ παθημάτων σύμβολα, καὶ τὰ γραφόμενα τῶν ἐν τῇ φωνῇ. καὶ ὥσπερ οὐδὲ γράμματα πᾶσι τὰ αὐτά, οὐδὲ φωναὶ αἱ αὐταί· ὧν μέντοι ταῦτα σημεῖα πρώτων, ταὐτὰ πᾶσι παθήματα τῆς ψυχῆς, καὶ ὧν ταῦτα ὁμοιώματα πράγματα ἤδη ταὐτά ('What is expressed by language are tokens of what is in the soul; what is come acute when another language (such as Latin) takes over science from the Greeks and its exponents lose their proficiency in Greek, which happened some eight centuries after Aristotle.

The terms that, as far as we can tell, were first used by Aristotle are not very numerous: there are some important philosophical ones, such as ἐνέργεια, ἐντελέχεια, and καθόλου; in addition, one occasionally finds *abstracta* such as ἀϊδιότης, or derived adjectives, such as ἐπιστημονικός, often in -κός, -τής, or -σις.[75] In his zoology, he occasionally needs names for groups of animals that do not have names yet, such as ὀστρακόδερμα ('shelled molluscs') and μαλακόστρακα ('crustaceans'); more rarely, there are similar cases in the physical sciences such as ἀντιπερίστασις ('reciprocal replacement, interchange'). Many more words are given new shades of meaning or are used more precisely (von Fritz 1938 called this 'Bedeutungsneuschöpfung'), such as κατηγορία ('category, head of predicables'), ὕλη ('matter'), or αἴτημα ('postulate').[76] Aristotle tried to structure his terminology, often as pairs of corresponding terms, especially contraries. Eucken

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written are tokens of what is expressed by language. And as writing is not the same for all peoples, so language is not either. But the affections of the soul of which these are tokens are the same for all men, and the things of which these are likenesses are also the same').

75 Eucken (1872: 25–26) collected a list of 'neue Ausdrücke' in philosophical terminology. Although in many cases it is not at all clear that Aristotle first used them, reproducing them here nonetheless gives a glimpse of the enormous influence his terminology was to have: ἀδιαίρετος (*individuus*), ἀδιάφορος (in logic), ἀϊδιότης, αἰσθητήριον, αἰτεῖσθαι, τὸ ἐν ἀρχῇ or τὸ ἐξ ἀρχῆς (*petitio principii*), αἰτιατός, ἄμεσος, ἀνάλυσις, ἀναλυτικῶς, ἀνομοιομερής, ἀντιδιαιρεῖσθαι, ἀντιπερίστασις, ἀντίφασις, ἀντιφατικῶς (only in *De interpretatione*), ἀποδεικτικός, ἀπόφανσις, ἀποφατικός, γενικός, διάρθρωσις, διαστολή, διχοτομία, εἰδητικός, εἰδοποιός, ἐκστατικός, ἐμπειρικός, ἐναντιότης, ἐνέργεια, ἐνθυμηματικός, ἑνότης, ἐνστατικός, ἐντελέχεια, ἐξωτερικός, ἐπακτικός, ἐπεισοδιώδης, ἐπιστημονικός, ἑτερογενής, ἑτερότης, ζωϊκός, ἠθικός, θεολογική, καταφατικός, κατηγορικός (*affirmativus*), κοσμικός, λογικός, μεταφορικός μονοπωλία, νοητικός, ὁλότης, ὁμοιομερής, ὀργανικός, ὁρικός, ὁρισμός, ὁριστικός, παθητικός, παραδειγματικός, περιπέτεια, πνεθματικός, ποσότης (only once), προβληματικός, πρότασις, προτατικός, σπερματικός, στερητικός, στοιχειώδης, συμπαθής, συμπέρασμα, συστοιχία, σωματικός, ταὐτότης, τοπικός, ὑλικός, φυσιολογία, φυτικός, ψυχικός. Something similar to what we have just described for Aristotle's science can be observed here: today, we do not share the basic outlook (e.g. about the nature of *Begriffe*) of the great (mostly German) philologists of the nineteenth century any longer, but we still gladly make use of their abundant data.

76 Eucken (1872: 26) also lists terms Aristotle uses in a new or stricter sense: αἴτημα, ἀκολουθεῖν, ἀκολούθησις, ἄκρα (*terminus minor* and *maior*), ἀντίθεσις, ἀντικατηγορεῖσθαι, ἀντικεῖσθαι, ἀντιστρέφειν, ἀξίωμα, ἀφαίρεσις, ἔκθεσις, ἐμπίπτειν, ἐναντίος, ἐνθύμημα, ἔνστασις, ἐνυπάρχειν, ἐπαγωγή, ἐπαλλάτειν, ἐπαμφοτερίζειν, ἔσχατον, ἴδιον, κατηγόρημα, κατηγορία, κεῖσθαι, λαμβάνειν, μέρος, μέσον, μετέχειν, ὁμογενής, ὁμώνυμος, παρέπεσθαι, περιέχειν, πρόσθεσις, πτῶσις, στέρησις, συγγενής, σχῆμα, συμβεβηκός, συμπεραίνεσθαι, σύμπτωμα, συνακολουθεῖν, σύνδεσμος, συνεχής, συνέχεια, σύνολον, ὕλη, ὑποκείμενον, ὑπόστασις.

(1872: 26) presents a list of such cases: γένος–εἶδος, ἕξις–διάθεσις, κίνησις–ἐνέργεια, σημεῖον–τεκμήριον, τύχη–ταὐτόματον, ἐνδεχόμενον–δυνατόν, συνώνυμα–ὁμώνυμα, ἀντίφασις–ἐναντίον, ποιεῖν–πράττειν, ἀφαίρεσις–πρόσθεσις, δύναμις–ἐνέργεια, ἐπαγωγή–συλλογισμός, οὐσία–συμβεβηκότα, παθητικός–ποιητικός, διαλεκτικός–ἀποδεικτικός, ὁμοιομερῆ–ἀνομοιομερῆ, ἀναλυτικῶς–λογικώς, πρότερον τῇ φύσει–πρὸς ἡμᾶς, ἄνω–κάτω (in logic), ἱστάναι–εἰς ἄπειρον ἰέναι.[77] This list will not be discussed in detail; it is quoted here only to suggest to the reader the 'flavour' of Aristotelian terminology and to emphasise the importance of this kind of *Fachsprache* in the further history of philosophy and science. Aristotle not only laid the foundations of basic scientific and logical methodology for the times to follow; he also had a fine sense for the use of concepts, often deploring that his language did not have a word for a genus or a group of things that would logically require one.[78] In general, Aristotle coins new terms when unavoidable,[79] but more often he expresses novelty by means of words or syntagms from common language, defining them more precisely or using them somewhat differently, most famously with his τὸ τί ἦν εἶναι ('the essential nature of a thing'). This seems to contrast with Democritus, who makes extensive use of the Greek language's rich possibilities for compounding (examples in §2 above). The exceptions where Aristotle did coin new words involve words that look very different from Democritus' poetic-sounding ones.

For later translators of Aristotelian science and philosophy into languages that do not easily form new compounds (such as Arabic and Latin), Aristotle's language made life much easier than, for instance, Democritus' texts would have.[80] As a brief digression, we can take a look at his two most famous coinings in metaphysics – ἐντελέχεια and ἐνέργεια – and how Latin translators dealt with them: both words were notoriously untranslatable in the Latin Middle Ages. Much has been written about these two words; in both cases the formation does not seem to have been unambiguous even to native speakers of Classical Greek. Graham (1989) summarises the discussion about ἐντελέχεια and points out that it is not derived from τέλος ἐν ἑαυτῷ ἔχειν ('having its end in itself'), but rather from ἐντελῶς ἔχειν ('to have completeness'), possibly hinting at Plato's use of

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77 A shorter list which, however, discusses the individual items can be found in Kullmann (1998: 25–28).

78 He tends to call these instances ἀνώνυμος; for passages, cf. Bonitz (s.v.). Such cases are especially frequent in his works on ethics but occur also in those on the natural sciences.

79 *Categoriae* 7, 7a5–6: ἐνίοτε δὲ καὶ ὀνοματοποιεῖν ἴσως ἀναγκαῖον ('Sometimes also forging names may be necessary').

80 Democritus may have written as much, and on such varied topics, as Aristotle. But textual transmission in Antiquity has preserved the one and not the other.

ἐνδελεχής ('perpetual').[81] At any rate, the word seems to be formed rather awkwardly, as new Greek compounds are usually clear enough to Greek-speakers. The oldest extant translations (by James of Venice and William of Moerbeke) of the *Physica* just write *entelechia* and may add *id est actio*. Later translators tended to simplify and just write *actus*, which, however, may also stand for several other Greek terms: ἐνέργεια, πρᾶξις, ποίημα, ἔργον, τὸ πράττειν.[82] Renaissance translators become more scrupulous about keeping Aristotelian concepts apart. Hermolaus Barbarus, apparently agreeing with the view championed by Graham, tries to translate it as *perfectihabia*.

Things are different for Aristotle's other new coining, that, although a near-synonym of ἐντελέχεια, has a more dynamic character: ἐνέργεια.[83] It is often paired with δύναμις, in the well-known conceptual pair δυνάμει–ἐνεργείᾳ, as 'potentially' versus 'actually'. This distinction is an attempt to lessen Parmenides' paradox, in which things become being from not-being; instead, according to Aristotle, they come from potential being (*Metaphysica* Λ2, 1069b15–20):

> μεταβάλλει πᾶν ἐκ τοῦ δυνάμει ὄντος εἰς τὸ ἐνεργείᾳ ὄν (οἷον ἐκ λευκοῦ δυνάμει εἰς τὸ ἐνεργείᾳ λευκόν, ὁμοίως δὲ καὶ ἐπ' αὐξήσεως καὶ φθίσεως), ὥστε οὐ μόνον κατὰ συμβεβηκὸς ἐνδέχεται γίγνεσθαι ἐκ μὴ ὄντος, ἀλλὰ καὶ ἐξ ὄντος γίγνεται πάντα, δυνάμει μέντοι ὄντος, ἐκ μὴ ὄντος δὲ ἐνεργείᾳ.
> 'Everything changes from potential being to actual being (like something that changes from potentially white to actually white, similarly with growth and decay), so that something can not only *per accidens* come into being from not-being, but everything can also come into being from being, though potential being, actual not-being.'

Both parts of this conceptual pair do not seem to have existed in Greek before Aristotle. But as δύναμις means (among other things) 'power, potential', δυνάμει was easily understood as 'in power, potentially'. Menn (1994: 75) observes that the corresponding new term ἐνέργεια can mean two things for Aristotle: 'actuality' and 'activity'; apparently, Aristotle first used the word to denote the latter meaning and progressively came closer to the former meaning. Aristotle also uses a verb ἐνεργεῖν ('to be in action, operate').[84] This verb is translated by Boethius as simple *ago*, by high mediaeval translators usually as *operor*. Renaissance translators often use *actu sum*, which fits better to *actus* in the established *actu–potentia* pair. The noun ἐνέργεια is usually rendered as *actus* from the very beginning, but it will make history in modern physics in its Greek form as *energia* ('energy').

81 See the response in Blair (1993).
82 Data from the word indexes of the *Physica* and *Metaphysica* volumes of *Aristoteles Latinus*.
83 See Menn (1994).
84 Later also used for e.g. medical or sexual 'operations' (loci in LSJ, s.v.).

Both of these new words become quite common in later Greek, but ἐντελέχεια remained a typically Aristotelian term.

§6 The contrast between scientific study before and after Aristotle – in Hellenistic times – is striking.[85] Many sciences were first tackled in depth either by him or by students of his school, the Peripatos,[86] which apparently for the first time provided an institution for organised scientific studies with its own library.[87] It was only loosely organised into older teachers and younger pupils, and was in general open to the public (in contrast to Pythagorean circles). Düring points out that 'Aristotle created something quite new with his school. […] finally, most important of all, the scientific outlook and the strictly scientific method' (quoted in Lynch 1972: 73–74). For Aristotle, ἐπιστήμη described his way of studying phenomena of all kinds using a variety of methods from mathematical and logical reasoning, observation (occasionally including simple experimentation),[88] questioning people who observed a phenomenon, and an extensive use of written sources (in his large library) that had accumulated to a quite considerable amount in the two centuries before him.[89] Aristotle himself added new data to the general 'stock', very clearly in his biological writings or his collection of constitutions of Greek city-states (see fig. 9).[90] Although Aristotle's own research has largely been revised in the subsequent millennia – he occasionally jumped from faulty observations to wide-ranging systems of thought built on sand – the main novelties in his own and his school's way of research lie in his detailed and organised programme for how to study things, including collaborators who took over some of the work and continued his school after his death, his self-conscious application of logic, and his thorough scrutiny of language, stressing the importance of precise definitions and differentiating between the different meanings of some words. Aristotle seems to have been the first person who thought methodically about the rôle of language in the expression of 'truth';[91] thus, according to the criterion of Léon Brillouin mentioned above (chap. 4 §6), Aristotle can be called the

85 See Lloyd (1979: 200). On the Lyceum, see Lynch (1972).
86 On which see Lynch (1972: 73–74).
87 On the Peripatetic school in Antiquity, see Moraux (1973–2001).
88 See Wöhrle (1986).
89 On Aristotle's way of working, see Flashar (2013: esp. 292). The sources are, unfortunately, largely lost to us today.
90 Collected by Aristotle and his collaborators; only the Athenian constitution has had the good fortune to be preserved on papyrus.
91 Plato's *Cratylus* may be seen as a predecessor.

first scientist. We try to illustrate this with a few passages from Aristotle that display the features with which we tried to demarcate science above (chap. 4 §5).

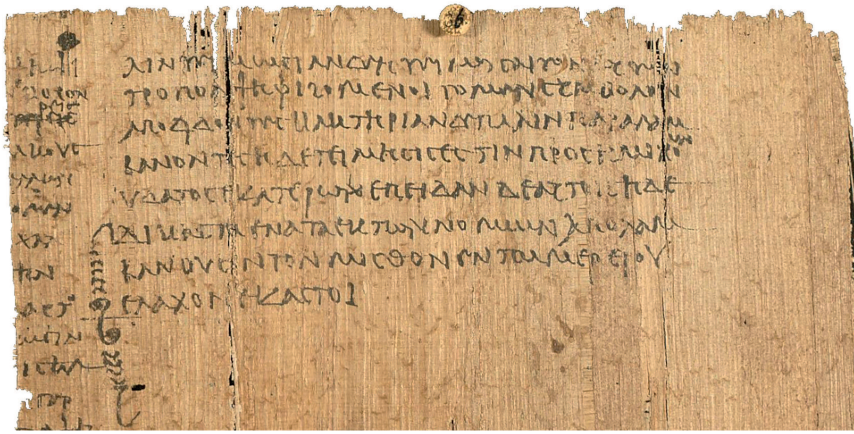

Fig. 9: The Athenian Constitution, the only surviving one of the city constitutions collected by Aristotle (British Library, Papyrus 131, part of 10v, the very end of the text, ca. AD 100). Source: https://commons.wikimedia.org/wiki/File:BL_Papyrus_131-10v_Constitution_of_Athens.jpg (image by user Dbachmann, public domain, modified).

(I) Systematic method. Aristotle studies scientific method in detail in his *Organon*. This does not always square with his actual methodology, but the latter (e.g. in biology) is also systematic, just of a more inductive kind. Indeed, discussions of methodology are present in many of his other works. Kullmann (1998: chap. 2) deals with this topic *in extenso*.

(II) Mechanisms. Above, the importance of causation for Aristotelian science was stressed (*Metaphysica* A2, 983a), as well as the need to show the 'how' (τὸ διότι), not only the 'that' (τὸ ὅτι). What we have called 'mechanisms' can be seen as a further development of this.

(III) Testability and impartiality. Examples of Aristotle's active gathering of data can be seen in many instances in his *Historia animalium* or in the collection of Greek city constitutions. In *De generatione animalium*, Aristotle points out that perception is to be trusted more than theory.[92]

92 *De generatione animalium* III.10, 760b30–32: οὐ μὴν εἴληπταί γε τὰ συμβαίνοντα ἱκανῶς, ἀλλ' ἐάν ποτε ληφθῇ τότε τῇ αἰσθήσει μᾶλλον τῶν λόγων πιστευτέον, καὶ τοῖς λόγοις ἐὰν ὁμολογούμενα δεικνύωσι τοῖς φαινομένοις ('[Speaking about the generation of bees:] the facts have not been ascertained sufficiently, but once they will have been, then sense perception must be believed

(IV) Non-sterility and coherence. Although we have seen that Aristotle stresses that every science needs its own principles, it is nonetheless clear that his sciences are interconnected. Much of the novel terminology, especially the pairs of contrasting terms, is used by Aristotle in many or all of them. The legacy of his research (or, in the above terminology, 'fruitfulness'), continued in the short run at his own school and in Alexandria, and in the long run in Arabic and Latin science, as will be shown below, is obvious.

(V) Community effort. The continued existence of Aristotle's school, where people did research and continued to teach for free and openly many generations after him, has already been mentioned. A good concrete example of community effort for Aristotle himself is, again, the collecting of Greek constitutions in order to study them, for which he collaborated with many people.

(VI) Formalisation. Aristotle formalised his language, as will have become clear above, especially in his novel pairs of contrasting terms. But he did not make much use of mathematical notation; in fact, no strictly mathematical works by him are known.[93] In the *Analytica priora*, Aristotle uses letters to denote statements and lays the ground for formalised, syllogistic logic.

Of course, it may be somewhat circular to find the characteristics of (Aristotelian-based) science in Aristotle – 'Wenn jemand ein Ding hinter einem Busche versteckt' (Nietzsche). The point of doing this, however, is to show that similar criteria can hold good at least for Aristotelian and present-day science. The question of the extent to which science is linked to Aristotelianism and the Greeks in general is taken up at the end of this study (chap. 24). As for the language used: it has been pointed out that Aristotle did not reflect much about how language should be used in science, but we can still consider how he himself used Greek – we again test our criteria from above (chap. 4 §7).

(i) Well-defined terminology. Aristotle usually defines his key terms and takes care not to make definitions that are too distant from then current linguistic usage. For completely new concepts, he occasionally coins new terms (such as ἐνέργεια, ἐντελέχεια), but more often he uses existing terms technically and defines them precisely.

(ii) Unambiguity. The phrase πολλαχῶς λέγεται occurs thirty-five times in Aristotle's works,[94] which is proof enough of the stress laid by Aristotle on the fact

more than theory, theories [must be believed only] if they show agreement with what is observed').

93 His relationship to mathematics was studied by Heath (1949) and Cleary (1995).

94 According to a Corpus Corporum search covering both sequences: πολλαχῶς λέγεται and λέγεται πολλαχῶς.

that language is often ambiguous and that the philosopher or scientist must therefore 'help' and improve natural language, making it a more precise tool.

(iii) Extendability. Some examples of newly coined words were listed above, but as Greek allows the nominalisation of phrases, this was often not even necessary; instead, such nominalisations as τὸ τί ἦν εἶναι, τὸ τίνος ἕνεκεν, τὸ τί ἐστιν are frequently encountered. The Greek language makes meeting this criterion easy; it will be less so for Latin.

(iv) Perspicuity. The surviving Aristotelian works are in different states of redaction: some of them are very clear (e.g. most of the *Organon* and much of his biology); in others the reader can feel the author grappling with his topic (e.g. parts of the *Physica* and *Metaphysica*).

(v) Modality. The Greek language is quite rich in expressing nuances of certainty. It can use optatives, subjunctives, particles, and of course adverbs. Occurrence of some traits in Aristotle were counted and compared to average *TLG* Greek (January 2018). Many of them are indeed more common in Aristotle (lemmata): ἴσως, ἄν, τις, φαίνω, ἔοικα, while some are not: τάχα, δύναμαι.[95] This is entirely to be expected, as such lemma frequencies depend a lot on personal style, but on the whole such words do seem to be more common than average in Aristotle. This aspect would need to be studied in greater depth.

The importance of Aristotle for the development of science in the long run will become obvious below: his works triggered Arabic scientific inquiry in the eighth century and the formation of Latin universities in the thirteenth. Well aware of this rôle, Dante calls him 'il maestro di color che sanno' ('the master of those who know'; *Inferno* IV.131, ed. Sanguineti, p. 25).

Hellenistic science and beyond

§7 Aristotle's school, the Lyceum, later also known as the Peripatos, continued his approach for several generations; his successor as head of the school, Theophrastus (scholarch 322–288), was even more 'first and foremost a man of science'.[96] Unfortunately, there is very little left of later Peripatetic works except

95 Occurrences compared to the most common word (the article), × 1,000: ἴσως 1.4 (*TLG*) vs 2.5 (Aristotle), ἄν 23.0 vs 37.2, τις 58.2 vs 84.6, φαίνω 4.7 vs 10.3, ἔοικα 2.6 vs 4.2; and the second group: τάχα 0.9 vs 0.3, δύναμαι 8.3 vs 7.0.

96 'Plato is a philosopher pure and simple; Aristotle is a man whose interest gradually turns from philosophical speculation to the study of detailed problems of natural science and history; Theophrastus is first and foremost a man of science' (Ross & Fobes in the edition of Theophrastus, *Metaphysica*, p. xxv). '[T]he aporetic and anti-dogmatic tendencies in Theophrastus are surely impressive' (Lloyd 1987: 154).

those by Aristotle and some of Theophrastus.[97] The school continued to function centuries after its founder's death, and at least the first few scholarchs continued along very similar lines: in particular, Theophrastus and Strato of Lampsacus (scholarch 288–ca. 269),[98] besides some other scientifically minded members such as Eudemus of Rhodes (ca. 370–ca. 300), who wrote exclusively (lost) ἀκροατικά, especially on the history of the mathematical sciences, are known by name. Later on, the difference between public works and those for advanced specialists seems to have become less pronounced and the school seems to have taken a more philological turn.[99]

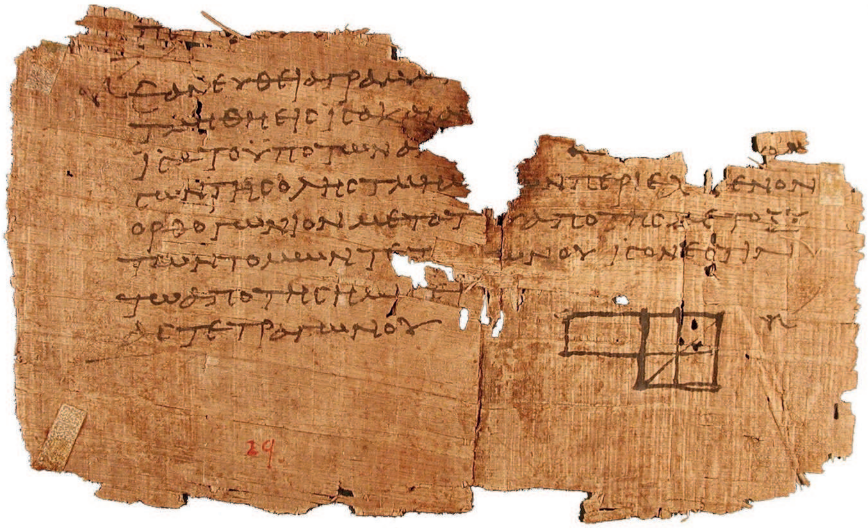

Fig. 10: The oldest known fragment of Euclid's *Elementa* II, prop. 6, including an unlabelled diagram (Papyrus Oxyrhynchus 29).
Source: https://commons.wikimedia.org/wiki/File:P._Oxy._I_29.jpg (image by user Jitse Niesen, public domain).

97 The fragments of the others are collected by Wehrli (1944–1978).
98 He corrected some Aristotelian mistakes. For instance, he found out that the central organ of thought is the brain, not the heart.
99 Under Lyco of Troas (ca. 269–225), Aristo of Ceos (225–ca. 190), Critolaus (ca. 190–155), Diodorus of Tyre (ca. 140), and Erymneus (ca. 110). With Andronicus of Rhodes (fl. ca. 60 BC) and his apparent recovery of Aristotle's esoteric works, a new era began, one marked mostly by the writing of scientific commentaries on the master's works.

In Hellenistic times, some schools, especially that at the Museion in Alexandria (in touch with Aristotle's)[100] and the one in Pergamon, became government sponsored, which, of course, sped up their advances significantly (recall the 'community effort' feature above). Both places also accumulated libraries of hitherto unseen size and quality. An important feature of Hellenistic and Roman times are the philosophical schools. Among them, Aristotle's remained the leading one for science in Antiquity. The other ones, especially the Platonists, Stoics, and Epicureans, focused less on scientific study and much more on ethics, and they tended to be more dogmatic.[101] Some very important Greek scientific works that were to set standards for the millennia to come were written in these Hellenistic and then, to a lesser degree, Roman times.[102] Unfortunately, most of Hellenistic science is lost, and we are even hardly informed about centres and schools. Prime examples of texts that became of great importance for the development of science in early modern times are Euclid's *Elementa* (see fig. 10; linguistically examined in chap. 22 below) for geometry, and from Roman times the works of Hero of Alexandria[103] for the development of mechanics and physics, as well as those of Ptolemy (ca. 100–ca. 170) for astronomy, and those of Galen (ca. 129–ca. 210) for medicine. Works of other, presumably important, scientific authors such as later Peripatetics, Alexandrian biologists, or the Stoic Posidonius (ca. 135–ca. 51 BC) are lost. Some of the extant authors tell us what they understood ἐπιστήμη to be; for instance, the great astronomer Claudius Ptolemaeus (*De iudicandi facultate et animi principatu,* ed. Lammert, vol. 3.2, p. 6) writes:

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100 On the famous library, see still Parsons (1952); the more recent summaries by Canfora and El-Abbadi cannot be recommended.

101 'Ganz anders das Werk des Aristoteles, welches erstens der Ethik keine beherrschende Stellung einräumte und dann im Gegensatz zu Stoa und Garten mit seiner wissenschaftlich-aporetischen Behandlung aller Probleme auf keine abschließende Dogmatik angelegt war' ('In contrast to the work of Aristotle, which, firstly, did not give a dominant position to ethics and then, in contrast to Stoa and Epicureans, was not pursuing a closed dogma with its scientific-aporetical treatment of all problems'; Wehrli 1944–1978: 10:95).

102 Russo (1997) argues that Hellenism is the real creator of science and that the ensuing Roman and mediaeval times suppressed it, only for it to be regained in Renaissance Latin circles. The importance of Hellenistic science is indeed great, but by finding no science in Aristotle and in the Latin twelfth to fifteenth centuries, it would seem that Russo takes over the biased and seriously dated convictions of some Renaissance humanists, denigrating the 'dark' Middle Ages and university Aristotelianism; see chap. 12 below. Despite this flaw, Russo's book still presents many interesting details in the history of the (especially mathematical) sciences.

103 See Boas (1949). Similar points could be made for Archimedes, Apollonius, or Diophantus, who all become influential in Latin translation in the sixteenth century.

> τούτου δ’ ἡ μὲν ἁπλῆ καὶ ἀδιάρθρωτος ἐπιβολὴ γίνεται δόξα καὶ οἴησις, ἡ δὲ τεχνικὴ καὶ ἀμετάπιστος, ἐπιστήμη καὶ γνῶσις.
> ‘the simple and unconnected application of it [i.e. thought] becomes opinion and point of view, one that is, according to the rules of art and unmovable by persuasion, science and knowledge.’

Thus, ἐπιστήμη is gained by rules of art and is to reach a degree of certainty that is not easily moved by rhetorical means. Here it is joined by γνῶσις, which can depict various types of knowledge (see chap. 3 §2). Ptolemy also speaks of κατάληψις ἐπιστημονική (‘scientific grasping’) in the *Almagest* (ed. Heiberg, vol. 1.1, p. 6), which is again βεβαίαν καὶ ἀμετάπιστον (‘certain and unmovable by persuasion’). Above, Galen was mentioned for his simile likening theory and observation to the two legs on which science moves forward (chap. 4 §5). The surviving works that have been mentioned changed science fundamentally when they finally became available again to Latin readers: Galen in the twelfth century, Euclid and Archimedes in the thirteenth, and all of them on the brink of the Scientific Revolution (sixteenth century). The rigorous structure of the *Elementa*, in particular, was to become a rôle model for a truly scientific approach. It was emulated in early modern times, for instance by Tartaglia’s *Nova scientia* (1537), Spinoza’s *Ethica ordine geometrico demonstrata* (1677), or Newton’s *Principia mathematica* (1687). Already in later Antiquity, there were dissenting voices to Aristotle, who did not use mathematical methods in natural science, such as Iamblichus (ca. 245–ca. 325), who advocates the use of mathematics in all sciences (*De communi mathematica scientia* 32, ed. Festa & Klein, p. 93):

> Ἔθος δ’ ἐστὶ τῇ μαθηματικῇ θεωρίᾳ καὶ περὶ αἰσθητῶν ἐνίοτε μαθηματικῶς ἐπιχειρεῖν, οἷον περὶ τῶν τεττάρων στοιχείων γεωμετρικῶς ἢ ἀριθμητικῶς ἢ ἁρμονικῶς, καὶ περὶ τῶν ἄλλων ὡσαύτως. [...] οὕτω γὰρ οἶμαι περὶ πάντων τῶν ἐν τῇ φύσει καὶ τῶν ἐν τῇ γενέσει μαθηματικῶς ἐπιχειροῦμεν.
> ‘It is customary for mathematical science to sometimes also tackle physical things, as when considering the four elements in a geometrical or arithmetical or harmonic way, and other fields similarly. [...] Thus, I think we should handle all physical things and all that comes to be in a mathematical way.’

What kind of language did these later authors use? The later philosophical schools, especially the Stoics,[104] continued to use much of the Aristotelian terminology, amplifying it in the fields they were especially interested in. In many scientific fields, the Aristotelian terminology was hardly changed but was used to express new insights. In metaphysics and theology, the neo-Platonists are an ex-

104 For examples of terminology, see Eucken (1879: 31–32).

ample of this: Plotinus hardly coins new terms (those he does are often compounds in ὑπερ-),[105] but although worldview and metaphysics are very different from Aristotle's (the well-known neo-Platonist hierarchical world of a kind of overflowing divine process in constant flux), he largely used Aristotelian terminology. It may be here that we have, for the first time since Plato (see above), serious scepticism regarding language's capability to describe the deeper layers of 'being' adequately (*Enneas* VI.8.13, ed. Henry & Schwyzer, vol. 3, p. 292):

> Δεῖ δὲ συγχωρεῖν τοῖς ὀνόμασιν, εἴ τις περὶ ἐκείνου λέγων ἐξ ἀνάγκης ἐνδείξεως ἕνεκα αὐτοῖς χρῆται, ἃ ἀκριβείᾳ οὐκ ἐῶμεν λέγεσθαι· λαμβανέτω δὲ καὶ τὸ οἷον ἐφ' ἑκάστου.
> 'We have to make a compromise with words whenever somebody necessarily has to use them when speaking about It [the divine One] in order to make apparent what strictly speaking is not expressible. But then a "so to speak" [τὸ οἷον] should always be implied in all cases.'

The further development of Roman and Byzantine science in Greek cannot be followed further here.[106] Suffice it to say that some fields flourished until the ἅλωσις (1453) and that they were written in Classical Greek, often using Aristotelian terminology. After two millennia, the Greek scientific and classical language traditions succumb under the τουρκοκρατία. As there was but little contact between Latin and Greek science in the Middle Ages up to the translation movement in the twelfth century, which relied on pre-Byzantine texts, it is not necessary for the present enterprise to pursue later Greek science and its language further. It may be added that Aristotle is the profane author for whom the greatest number of Byzantine manuscripts survive: more than one thousand.[107] They were to feed the Latin translation movement.

§8 So, to summarise, we can recognise a new, scientific *Denkstil* that can be traced from the sixth century BC and more clearly from the fifth onward, for instance in writers such as Parmenides and Anaxagoras, and somewhat later in a more definite and self-conscious form in some of the Hippocratic medical writers, in historians, and in Democritus; but the crucial factor in the genesis of science was reflection on language and its relation to knowledge. This reflection can be seen in Plato's dialectic, which in turn can be seen as a reply to the sophists' claim

105 Such as ὑπεράνω, ὑπερβεβηκός, ὑπερευδαίμων, ὑπέρκαλος, ὑπερκείμενον, ὑπερόντως, … (source: *TLG* word-list for Plotinus).
106 For the latter, see now Lazaris (2020), which can only partly be recommended; important topics are missing, and (worse) the book is teeming with typographical errors and some chapters are written in appalling English. See still Hunger (1978).
107 In contrast 'only' some 260 for Plato (Isépy 2016: 11).

of being able to make any λόγος win in debate.[108] Plato's Socrates changes the sophists' end – it becomes truth – while keeping their means, as can be well seen, for instance, in Plato's *Gorgias*. Plato remained sceptical about reaching 'scientific' knowledge of changeable things, and only his pupil Aristotle and his school applied this kind of dialectic inquisitiveness decidedly to all kinds of phenomena, including the changeable world. This may be seen as the actual birth of science, an Aristotelian *Denkstil*. After Aristotle, many of his scientific and philosophical approaches are further developed. Many of them will be taken up in the Late Middle Ages when they finally reach the Latin medium. Aristotle made some compromises concerning the early ideals of certainty and necessity (see chap. 4 §3): he is cautious enough to stress that science describes that which happens all the time or most of the time; besides, there are phenomena that do happen occasionally but neither always nor usually. Whether such phenomena can be and should be described by science does not become clear in Aristotle's works. Modern statistical approaches have been able to group many such occasionally happening phenomena into larger classes and to study them scientifically.

108 A surviving example of such a proclamation is the encomium of Helen by Gorgias, the alleged cause of the Trojan War.

8 Foundations of Roman science in Latin

> Man kann, vielleicht etwas überspitzt, sagen, dass die lateinische Literatur ihrer Wurzel und ihrem Wesen nach Übersetzungsliteratur im weiteren Sinne ist und dass die Sprach- und Stilmittel der lateinischen Hoch- und Literatursprache in Poesie und Prosa weitgehend auf dem Boden der Übertragung aus dem Griechischen gewachsen sind und sich entfaltet haben.
> 'It can be said, perhaps exaggerating somewhat, that Latin literature is, in its roots and nature, translation literature in a broad sense, and that the linguistic and stylistic devices of Latin standard and literary language in poetry and prose largely grew and developed on the ground of translations from Greek.'
>
> Puelma (1980: 139)

§1 In the previous chapter, we identified a newly emerging *Denkstil* in Greek medicine, historiography, Aristotelianism, and Hellenistic science whose common property is striving for the greatest possible certainty. It took the Romans time to adopt and take over parts of this Greek *Denkstil*, as will be seen in this chapter; in most fields, this was a conscious process of borrowing. This chapter will cover the institutional background for science in Rome (§2), the beginnings of learning expressed in Latin (§3), the three crucial early authors Varro, Lucretius, and Cicero (§§4–7), some later imperial authors and texts that might pass as scientific (§§8–11), and that most Roman 'science', jurisprudence (§12). In general, the Romans were less interested in theoretical science and more in practical arts. As Stahl (1971: 241) puts it:

> The Greeks, the Wunderkinder of intellectual history, first propounded and pursued ideas for ideas' sake. The Roman penchant for doing rather than wondering represents a return to normalcy.

As we have seen above (chaps 2–3), there was no consensus as to what Roman word should stand for such Greek science: often *disciplina* was used, besides *ars*, sometimes *scientia*, or even other terms. Although there is quite a lot of Roman learning in Latin texts, in most cases it remains questionable whether it can be addressed as science. The few remains of *Fachprosa* from the later second and the early first century BC, the time when Greek influence and especially Stoic philosophy entered Rome, visible for instance in the circle of men around the two Scipios,[1] have been studied in detail by Suerbaum et al. (2002). The scanty surviving material about potentially scientific writers before the three obvious first candidates (Varro, Lucretius, Cicero) will be examined below (§3). Indeed, the Latin

1 See Alesse (2017), with further references.

https://doi.org/10.1515/9783110745832-009

standard language itself became fixed[2] precisely in the last decades of the Republic and in the early reign of Augustus.[3] In order to be able to speak about scientific matters, a standardised, stable language, capable of expressing and preserving insights, is of paramount importance. In the case of Cicero, it will become clear that this language is still very much in the making, with Cicero working on it consciously. The kind of literary Latin[4] fixed in this period was to remain the standard form of the language ever since (not only for science), although the spoken language, of course, kept on developing and changing, finally turning into the Romance dialects. This fixing of Latin may be seen as a conscious though only partly successful attempt to supplant Greek as the language of literature, including philosophical and scientific literature, in Rome.[5] Its main internal stimuli were law and oratory.[6] However, Greek remained common knowledge among educated men until Late Antiquity, and many Romans preferred to write their texts in Greek. The first known Roman to write a *Fachtext*, the historiographer Quintus Fabius Pictor (fl. ca. 200 BC), did so in Greek.[7] Some other republican Romans who wrote scholarly works in Greek are known, for instance Licinius Lucullus on the *bellum marsicum,* or even occasionally Cicero himself.[8] Only in Cicero's time was the first public library in Rome founded by Asinius Pollio (75 BC–AD 4); it had a Greek and a Latin section, as did later public libraries founded by Augustus.[9] Varro was its librarian. The problem of higher learning in Latin is well explained by Cicero's *Academica* (I.2, ed. Plasberg, p. 4), where the interlocutor Varro tells him why he had long refrained from writing a Latin work on philosophy:

> *nam cum philosophiam viderem diligentissime Graecis litteris explicatam, existimavi si qui de nostris eius studio tenerentur, si essent Graecis doctrinis eruditi, Graeca potius quam nostra lecturos, sin a Graecorum artibus et disciplinis abhorrerent, ne haec quidem curaturos, quae sine eruditione Graeca intellegi non possunt. Itaque ea nolui scribere quae nec indocti intellegere possent nec docti legere curarent.*

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2 See the discussion on the vitality and death of Latin at certain times in chap. 16 §1 below.
3 Similarly Leonhardt (2013: 57).
4 On some aspects of its formation, see Marouzeau (1949) and Neumann (1977).
5 See Leonhardt (2013: 73).
6 Von Albrecht (1992–1994: 1:39).
7 Known from Dionysius of Halicarnassus, *Antiquitates Romanae* I.74.1, ed. Fromentin, p. 189. On this author, see Timpe (1972).
8 As he mentions in *Epistolae ad Atticum* I.19.10, ed. Watt, p. 40. Lucullus' work is also mentioned there, as well as in Plutarch, *Vitae parallelae* Lucullus 1.8, ed. Ziegler, vol. 1, p. 360: διασῴζεται γὰρ Ἑλληνική τις ἱστορία τοῦ Μαρσικοῦ πολέμου ('A Greek history of the Marsic War has survived').
9 Pöhlmann (1994: 65) provides a good overview of libraries in Antiquity.

> ‘As I saw that philosophy was most diligently explained in Greek writings, I supposed that if some of us [Romans] wish to study it, they should, if they are schooled in Greek letters, rather read Greek books than ours [Latin ones], if they do not detest the arts and sciences of the Greeks, so that they will not care about things that cannot be understood without a Greek education. Therefore, I did not want to write what neither uneducated people can read nor educated people care to read.’

Indeed, quite in general, Latin was not much used for theoretical scientific or philosophical studies in Roman times.[10] Upper-class Romans were fluent in Greek; indeed, parents often sent their children to Greek schools in the East. To all intents and purposes, the Roman Empire used Latin in its Western half and Greek in its Eastern half for official purposes. Thus, translation of imperial documents, decrees, and similar texts from Latin into Greek had to be a routine procedure. Conversely, it is striking that we know only of very few instances of literary, philosophical, or scientific works being translated between these two languages. Clearly, many regarded the Latin language as incapable of expressing higher learning adequately, and considered such topics as belonging to a Greek *Denkstil* that should be read in Greek. This phenomenon of a lack of theoretical studies in Latin is not infrequently referred to in Latin literature, sometimes as the *patrii sermonis egestas*,[11] and it becomes quite topical.[12] An illustrative example of the veneration of Greek from the middle of the second century AD is Aulus Gellius (*Noctes atticae* X.22.3, ed. Marache, vol. 3, pp. 179–180), who writes:

> *Verba ipsa super hac re Platonis ex libro, qui appellatur Gorgias, scripsi, quoniam vertere ea consilium non fuit, cum ad proprietates eorum nequaquam possit Latina oratio aspirare ac multo minus etiam mea: [...].*
> ‘I have copied these words of Plato about this topic from the book called Gorgias, because it did not seem meet to translate them, as the Latin language can in no manner aspire to their properties, and even less my Latin: [a long quotation from Plato’s Gorgias in Greek follows].’

Similarly, many authors argue that the Roman mind was more set on practical things, so we do know of texts by *agrimensores*, medical texts, texts on technical matters in general, introductory *compendia*, and the like. Even Roman philosophy takes on a rather practical bent in writers such as Cicero (rhetoric and politics) or

10 See Stahl (1962). Von Albrecht, speaking of Latin Antiquity: ‘Wissenschaftliche Forschung im strengen Sinne ist und bleibt weitgehend eine griechische Domäne’ (‘Scientific research in the strict sense is and remains largely a Greek domain’; 1992–1994: 1:450); Ogilvie (2015: 270) writes that ‘most serious ancient scientific works were written in Greek’.
11 On which see Fögen (2000).
12 That something becomes a topos implies, however, that it was perceived as a fact at some point.

Seneca (Stoic ethics aiming at ἀπάθεια). Thus, Stahl wrote an entire book about something which according to him hardly existed: 'Roman science'; indeed, he often seemed to get frustrated with his field of study.[13] The picture that emerges of 'Roman' 'science' from the beginnings up to the twelfth century is mostly one of the copying of translated textbooks from one generation to the next, of ever-decreasing quality, of 'secondhand information, an uncritical approach, inconsistencies, failure to acknowledge sources, lack of structure' (Stahl 1971: 96). This picture is a largely appropriate portrayal of mathematical and strictly theoretical studies, as far as we can tell on the basis of the surviving texts. These fields, indeed, seem to have had little appeal for Romans – but things look different in applied sciences (*artes*) and in non-natural sciences, such as agricultural technology, medicine, grammar, historiography, and most importantly jurisprudence, widely cultivated by Latin writers in Antiquity and beyond.[14] Jurisprudence was developed into a scientific activity by the Romans. Its original language is consequently Latin, and juridical works were – unusually – translated from Latin into Greek, where Latin terms were often simply reproduced in Greek (see §12). Moreover, from the third century onward, Christian theology was much practised among the Church Fathers and was perceived as a kind of scientific, not only scholarly or even purely speculative, activity, as they tried to elucidate the relationship between the divinity and the world – Incarnation, Trinity, etc. – in contact and confrontation with the state-of-the-art scientific theology of their time: neo-Platonism (see chap. 9 §2). Nonetheless, the topos that Latin is unfit for Greek *disciplinae* such as *dialectica* is still alive and well in the fifth century AD, as can be seen in Martianus Capella (*De nuptiis Philologiae et Mercurii* IV, §334, ed. Ferré, p. 6), where personified *Dialectica* speaks but *parum digne* in Latin:

> *Ac mox Dialectica, quamquam parum digne Latine loqui posse crederetur, tamen promptiore fiducia restrictisque quadam obtutus vibratione luminibus etiam, ante verba formidabilis sic exorsa: [...].*
> 'And all of a sudden Dialectica, although it was thought that she can hardly speak decent Latin, yet with greater confidence, her eyes stern with but a slight quiver of her glance, and impressive even before uttering a word, she began thus: [...].'

13 'Roman science has been a much neglected field of study. Because it can be reasonably asked not only whether it was really science but whether it was Roman, many authorities avoid the second question and warily refer to Greco-Roman science' (Stahl 1962: 3). 'Scientific knowledge in Roman times never rose above the lowest level of Greek popular science' (251).

14 Indeed, Stahl admits readily that the picture would be very different if not only theoretical science but also technology were to be considered.

Institutions for science and *Sitz im Leben*

§2 It is of crucial importance for activities such as science to have a *Sitz im Leben* in a society from which they can continue being practised from generation to generation and develop further. If they do not, they are at best cultivated by some eccentrics who stand high chances of soon being forgotten (recall the 'community effort' criterion in chap. 4). Today, and since the thirteenth century, this place is usually the university. In early modern times, there were also erudite societies; in Greek Antiquity, private and to some extent state-sponsored Hellenistic schools.[15] Indeed, the number of people in Antiquity that would pass as scientists was small; even including scientifically working philologists, historians, and logicians, the number would remain modest. It was certainly the roughly two centuries after Aristotle that were most fruitful for the sciences, precisely due to state patronage in Alexandria and Pergamon.[16]

There were no similar university-like institutions teaching more theoretical sciences in the Roman Empire, and the change from Hellenism to the Roman Empire proved to be a setback for the development of science.[17] At least some emperors financed chairs for rhetoric and philosophy, and there was, apparently, occasionally an attempt to found more ambitious university-like structures, such as an institution apparently called the Athenaeum, a *ludus ingenuarum artium* in Rome under Hadrian.[18] As Hadot (1984: 252) concluded, higher studies were done as part of the philosophy curriculum, which – depending on the teacher's school – included mathematics and natural sciences to varying degrees; in the case of Platonists, hardly any of the latter, for Peripatetics and Stoics, a little of both. The strong neo-Platonic current in Christianity may help to explain why the Early Middle Ages took over the Seven Liberal Arts (chap. 9 §1), which lack natural science proper. Sulla's destruction of the Academy and its reappearance only when the Roman Empire had become Christian may be seen as symptomatic for the Romans' lack of interest in theoretical studies.

15 On ancient Greece, see Lloyd (1987: 330–336), concluding: 'Even among the literate elite themselves, the gap between those who were capable of independent research and those who merely know something about it was very great, as the immensely learned, but at points quite uncritical and confused, Pliny illustrates' (331).

16 This is also stressed by Lloyd (1973: 3 and *passim*); it is one of the main points of Russo (1997).

17 In Demandt (1999), a collection of essays treating important universities, there is a conspicuous gap between Alexandria and Constantinople.

18 See Aurelius Victor, *De caesaribus* 14.3, ed. Pichlmayr, p. 93. Details in Barbagallo (1911: 130–135). In general on Roman state-run schools, see *Pauly's Real-Encyclopädie* (s.v. 'Schulen (Rom)', by Erich Ziebarth). Much depended on the emperor in charge; there was no continuity.

In contrast to classical Greek and Hellenistic times, the people who engaged in scientific activities in the widest sense tended to be found at the imperial court, either as gentleman scientists from senatorial ranks who were also politically active and often died violent deaths (such as Cicero or Seneca) or as teachers of philosophy or rhetoric (Quintilian), often from the Eastern half of the Empire; or they engaged in practical arts such as medicine or law, often also based in the capital, many of them writing in Greek (e.g. Epictetus, Galen, Marcus Aurelius, Claudius Aelianus, Plotinus). At court, there was at best some interest in doxography of the kind: this philosophical school believes the cause of, say, earthquakes to be this, and that that, with no attempts to verify or refute these δόξαι.[19] Of course, there were schools for more practical arts such as medicine, oratory, or law in the Roman Empire. For law there was the important school in Berytus (Beirut),[20] teaching at 'university' level, as well as another one in Rome; at both, including the former, despite its location in the East, Latin was used as the scientific language of law.[21] In the fifth century, a rival school in Constantinople was set up. These schools had fixed professor posts and offered a five-year curriculum to students.[22] Indeed, law may in many respects be the scientific endeavour that most befitted the Roman mind and the one in which the Romans surpassed the Greeks.

Just as a *Sitz im Leben* for the more theoretical sciences did not exist in the Roman Empire, so too there did not exist one clear-cut style for those few authors who did write about them. In contrast, as we have seen (chap. 6 §4), Roman stylistics offers quite narrow criteria for the writing of many other genres, such as letters, epic poetry, or panegyrics. This stylistic theory continued to be used and to be highly influential in the Middle Ages and early modern times.[23] As this was not the case for scientific texts, it is to be expected that scientists would copy each other's style, or that of their Greek predecessors, and that several currents would be identifiable.[24] After these preliminary considerations, we now survey some Roman authors, what they feel about science, and what kind of language they use or recommend.

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19 The anonymous poem *Aetna* can serve as an example; see §8 below.

20 Probably founded in the late second century AD; see Jones Hall (2004).

21 Although probably not as the language of teaching; see Schulz (1961: 347) and Parker (1992: 272) for its development in the fifth century.

22 Söllner (1996: 132).

23 See Auerbach (1958).

24 Korenjak speaks of 'Wildwuchs' ('rank growth'; 2016: 70).

The beginnings of science in Rome

§3 Very little Latin literature survives from before the time of Varro and Cicero. Before then, we know of some learned literature, but one doubts whether much of it was of a scientific nature, even if taken in a very wide sense; in general, writing among the still rather unsophisticated Romans will have been modest, with the one exception of jurisprudence, for which the Romans seem to have had a special affinity from early on. Jurisprudence as a scientific undertaking, in the sense that it sought theory-based systematic generality and had its own specialists,[25] is described by Manthe thus: 'die klassische Rechtswissenschaft untersucht die grundlegenden Beziehungen der menschlichen Gesellschaft und hat allgemeingültige Lösungen für ihre Probleme gefunden' ('classical jurisprudence examines the fundamental relationships of human society and has found universal solutions to its problems'; in Graf 1997: 455).

The beginnings of Roman law and its distinctive language should be considered in this context.[26] Only scanty remains of old Roman law are extant, partly from inscriptions, partly from later quotations. The crucial first act of legislation in Rome was the L e g e s d u o d e c i m t a b u l a r u m (traditional date: 450 BC).[27] Their language was, of course, still very archaic, and they are famous for their epigrammatic character, as this example shows:

> *Si in ius uocat, ito; ni it, antestamino; igitur im capito.*
> 'If someone calls to court, one must go. If not, a witness is to be taken. Thus he is to be seized.'

For such an old legal collection, the Twelve Tables are remarkably detailed, but they are very different from the scientific Roman law of imperial times. Their language is simple; by far most commonly, conditional phrases with *si* or *ni(si)* are found, usually followed by imperatives in the third person. The often-changing grammatical subjects must be inferred from context. In order to reach such generality, a technical vocabulary of its own had to be developed; some abstract, legal technical terms are already discernible in the Twelve Tables, for instance *auctoritas* ('warrant') or *intestabilis* ('incapable, by reason of misconduct, of being a witness or of making a will').[28] The Twelve Tables laws are still comparable to con-

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25 Cicero often speaks of *iuris civilis scientia* ('the knowledge/science of civil law'); Schiavone (2007: 122) also emphasises its scientific character.

26 Good introductions to its development are Schulz (1961) and Söllner (1996).

27 Edition: *Roman statutes*, ed. Crawford, vol. 2, p. 578. On the collection's language: p. 571.

28 Translations from Lewis & Short.

temporary Greek models such as the laws of Lycurgus for Sparta, or of Dracon and Solon for Athens, or the surviving Cretan Gortyn laws.[29]

After a period of Hellenisation in the second century, Greek ways of thinking, including Greek philosophy and science, were introduced to a certain degree in Rome. Marcus Porcius Cato (234–149 BC) illustrates very well the advent of Greek thinking in Rome and both the reluctance to engage with it and the fascination with doing so.[30] This Hellenisation made Greek dialectic enter jurisprudence, as can be seen in the new importance of eloquence and use of Aristotelian terms such as *differentia, genus, species*.[31] Sextus Aelius Paetus Catus (fl. 198–194 BC) wrote a first juridical work in this vein, the *Commentaria tripertita,* apparently developing law out of the Twelve Tables.[32] Unfortunately, the work is completely lost, but it was praised by Cicero.[33] Specialised jurisprudence that can be called scientific in the above sense, seems to begin in Rome at the latest around 100 BC, especially with the *pontifex* Quintus Mucius Scaevola (ca. 140–82) and his influential (lost) work *Ius civile*. Greek philosophical influence seems to be tangible in him: he defined juristic terms and, again, operated with *genera* and *species*.[34] In Cicero's time, there were already professionals, such as his friend Servius Sulpicius Rufus. As in Roman law courts a side committing formal errors had *eo ipso* lost its case, it became of paramount importance to be precise and to stick to the juridical rules meticulously. However, Roman law remained an *ars* and despite Cicero's apparent endeavours[35] did not become a *scientia* based on first principles

29 Livy relates that the Romans had sent a delegation to Greece to be informed on how laws should be organised (*Ab urbe condita* III.34, ed. Bayet et al., vol. 3, pp. 51–52). Although this is usually not taken at face value by modern historians, it still shows that even in jurisprudence the Romans acknowledged a debt to the Greeks (for which see e.g. Jörs, Kunkel & Wenger 1949: §4.3, p. 5). On the other hand, even the elementary term *poena* is a Greek loanword.

30 On this author and his life, see Astin (1978). On the Romans' relationship to Greek, see Kaimio (1979).

31 See Schulz (1961: 73).

32 Schulz (1961: 41–42); the three parts covered the text of the Twelve Tables, a commentary, and process formulas,

33 *De re publica* I.18 (30), ed. Ziegler, p. 20.

34 See Jörs, Kunkel & Wenger (1949: §14.4, p. 23), quoting Gaius, *Institutiones* I.188, ed. Manthe, p. 104, and Augustine, *De civitate Dei* IV.27, ed. Hoffmann, vol. 1, pp. 197–199. Later times are still aware of this foundational work; cf. *Digesta* D 1.1.2, ed. Krüger & Mommsen: *Post hos fuerunt Publius Mucius et Brutus et Manilius, qui fundauerunt ius ciuile* ('After these there were Publius Mucius, Brutus, and Manilius, who founded civil law'). The newer reworked edition of Jörs by Heinrich Honsell et al. (4th ed., Berlin, 1987) has removed this paragraph, apparently seen as too philological.

35 In his lost *De iure civili in artem redigendo*. As Schulz put it 'Die römische Jurisprudenz hat diese Ermahnungen mit höflichem Schweigen beantwortet' ('Roman jurisprudence answered these admonitions with polite silence'; 1934: 44).

with a deductive structure. Indeed, it remained surprisingly tolerant of previous legal approaches in the provinces of the Empire, as can still be seen in the papyrus evidence from the Roman province of Egypt.[36] Roman juridical methods remained casuistic; as Söllner (1996: 105) puts it:

> Solche Regeln, Grundsätze und Prinzipien wurden mit äußerster Vorsicht formuliert. Sie betrafen immer nur abgegrenzte Fallgruppen. Die römische Jurisprudenz befasst sich mit Einzelfällen und deren sachgerechter Lösung. Gegen eine allzu abstrakte Begrifflichkeit und gegen das Argumentieren mit allgemeinen Rechtsgrundsätzen bestand eine starke Abneigung.
> 'Such rules, principles, and policies were formulated with extreme caution. They always concerned only delimited groups of cases. Roman jurisprudence is concerned with individual cases and their proper resolution. There was a strong aversion to overly abstract terminology and to arguing with general principles of law.'

Apparently, Roman jurists saw reality as too complex for fixed definitions and rules. The oft-quoted Roman warning against 'scientific' definitions (understood in a broad sense as covering all fixed juridic rules) instead of casuistics is found in Justinian's *Digesta* L 17.202, ed. Krüger & Mommsen:

> *Omnis definitio in iure ciuili periculosa est: parum est enim, ut non subuerti posset.*
> 'Each definition in civil law is dangerous, for it is rare that it cannot be overthrown [by some cases].'

Definitions such as Ulpianus' *Ius est ars boni et aequi* ('Law is the art of what is good and just')[37] are only used at the beginning of works and play a more ornamental rôle. Thus, Roman law may qualify as a science according to broad criteria, but in Antiquity it would not have been seen as an ἐπιστήμη by Aristotelians. On the other hand, it kept a clear and central rôle in Roman society, in contrast to most other sciences (Schulz 1961: 84):

> Wenn so die römische Jurisprudenz sich zu einer Wissenschaft im eigentlichen und strengen Sinne entwickelte, so blieb sie doch eine Wissenschaft römischer Staatspriester, Senatoren, Magistrate und *iuris consulti*, d. h. von Männern, die mitten im praktischen Staats- und Rechtsleben stehen. Daraus ergab sich ihre klare Abgrenzung zu anderen Wissenschaften.
> 'Even if Roman jurisprudence thus developed into a science in the strictest and most rigorous sense, it remained a science of Roman state priests, senators, magistrates, and *iuris consulti*, that is, of men from the midst of practical state and legal life. This was the reason for its clear demarcation from other sciences.'

36 See Alonso (2013) on the status of 'peregrine law' in Egypt.
37 *Digesta* D 1.1.1 pr., ed. Krüger & Mommsen, vol. 1, p. 1; on the author, see below.

The language of late republican and early imperial Roman law is poorly known,[38] but it is clear that it was already perceived by contemporary Romans as a technical language not easily understandable to laymen. It has been characterised as using archaisms, precision involving a lack of metaphors, and – in contrast to other early scientific Latin – a lack of Greek terms.[39] Its further development toward 'classical' Roman law (second to third century AD) is pursued below (§12).

Unfortunately, the beginnings of Latin's deliberate use as a medium for the other, more typically Greek, sciences and philosophy are even less accessible today. Romans before the first century BC will certainly have talked about things important for their life and the administration of their growing empire as well as about Greek learning, but practically nothing has come down to us except Cato's *De agri cultura*. This learned *Fachbuch* describes how to work a large-scale Roman farm; even by a very broad definition, it cannot be called 'scientific', although it does shed some light on the importance of Greek influence in Cato's time. There are close to no surviving documents from the following century, although the existence of some scholars is known, for instance the grammarian and historian Lucius Aelius Stilo Praeconinus (ca. 154–74 BC), teacher both of Varro and of Cicero, but none of his works is extant.[40] The same is true for the historian Lucius Cornelius Sisenna (ca. 120–67 BC).[41]

Late republican and Augustan imperial times

§4 The three important learned authors of surviving texts from the late Republic – Varro, Lucretius, and Cicero – all show the importance of Greek or, indeed, consciously try to break its monopoly; they are already heavily Hellenised. In their time, some other scientific writers are known by name – such as Marcus Verrius Flaccus (ca. 55 BC–AD 20), who wrote grammatical treatises and a very voluminous dictionary, or Nigidius Figulus' (ca. 98–45) equally voluminous *Commentarii grammatici* – but their texts are lost.[42] The three main authors were contempor-

38 'Eine systematische Merkmalsbeschreibung und Charakterisierung der römischen Rechtssprache überhaupt und ihrer unterschiedlichen Genera bleibt ein Desiderat der klassischen Philologie und historischen Sprachwissenschaft' ('A systematic description and characterisation of the Roman legal language in general and its various genera remains a desideratum of classical philology and historical linguistics'; Gebhardt 2009: 34). Some points about juridical Latin in republican times are made in Schulz (1961: 113–116).

39 See Gebhardt (2009: 14–15).

40 e.g. Suetonius, *De grammaticis* 3, ed. Kaster, p. 6, mentions him.

41 Some fragments survive: Cornell (2013).

42 The former's dictionary was epitomised by Sextus Pompeius Festus' (second century AD) *De verborum significatu*; see Glinister & Woods (2007).

aries of one another, and the oldest of them (Varro) outlived the other two. It will become clear that none of them can strictly be called a scientist: Lucretius was more a poet wanting to share his Epicurean convictions, making use of doxographic science for this end, while Cicero was more a politician and rhetorician with an interest in Greek philosophy. Varro was a scholar; those of his works that may have most deserved to be called scientific are, unfortunately, lost. Nonetheless, all of these three authors were crucial in enriching Latin's expressive capabilities. Before their time, no specialised philosophical or scientific vocabulary in Latin seems to have existed (excepting jurisprudence).[43]

§5 Marcus Terentius Varro (the older, 116–27 BC)[44] was a prolific writer and student of Roman antiquities and their language and culture, who worked in a scholarly manner. For Quintilian he was the *vir romanorum eruditissimus*.[45] Unfortunately, most of his numerous works filling some 620 scrolls[46] are lost. He apparently borrowed much from (also lost) Greek compendia. Many titles of his numerous works are known; some of them betray an interest in natural science, such as *De aestuariis* ('On Tidal Inlets').[47] As Stahl puts it, 'Varro's work seems to have been the fountain-head of much of the subsequent Latin scientific literature' (1971: 4). His treatise *De disciplinis* in nine books, in particular, would be very interesting to study in the present context, but only very few fragments survive and it is not even clear which books treated what discipline.[48] Some of the few surviving fragments make one wonder whether their content was not more of an antiquarian and etymological nature than actually about the disciplines' scientific content.[49] Cicero aptly calls him *Varro noster diligentissimus investigator antiquitatis*.[50] But in other cases, this is clearly not his sole interest, for instance in his descriptive study of religion, where he may have coined the phrase *theologia naturalis* (in his *Antiquitates*).[51]

43 See Leonard & Smith's edition of Lucretius, p. 217.
44 Introductions: Cardauns (2001); Lehmann (1997).
45 *Institutio oratoria* X.1.95, ed. Rahn, vol. 2, p. 468.
46 See Kent's edition, vol. 1, p. viii. The existence of many of them is only known from a list compiled by Jerome. For a full list, see Della Corte (1970: 255–257).
47 Mentioned in *De lingua latina* IX.19(26), ed. Goetz & Schoell, p. 152.
48 Ritschl, *De M. Terentii Varronis*, collected references to it and fragments from it. However, he was over-optimistic in his conclusions based on very scanty evidence.
49 e.g. *stella a stando* ('"star" is said because it "stands" still [in contrast to planets]') is one of these fragments, apparently from the book on astronomy; from Cassiodorus, *Institutiones* II.7.2, ed. Mynors, p. 155.
50 *Brutus* 15(60), ed. Martha, p. 21.
51 No longer extant, but quoted by Augustine, *De civitate Dei* VII.7, ed. Hoffmann, vol. 1, p. 131. The fragments are collected in Varro, *Antiquitates rerum divinarum*, ed. Cardauns.

His two surviving works are one on agriculture and books 5–10 (of 25) of *De lingua latina* in a rather corrupt textual form. Besides his interest in antiquarian matters, a scientific spirit becomes apparent in this author every now and then. For instance, he seems to inform his readers of the existence of microbes when speaking of what would seem to be malaria and wisely advises building the homes of farm slaves away from swamps (*De re rustica* I.12.2, ed. Flach, vol. 1, pp. 110–111):

> *Advertendum etiam, siqua erunt loca palustria, et propter easdem causas, et quod ‹cum› arescunt, crescunt animalia quaedam minuta, quae non possunt oculi consequi, et per aera intus in corpus per os ac nares perveniunt atque efficiunt difficilis morbos.*[52]
> ‘Precautions must also be taken if there are swampy areas, both for the mentioned reasons and because when they dry out, minute animals grow that the eye cannot discern, and – airborne – they enter the body through the mouth and the nose and cause serious diseases.’

Of course, it is unknown whether this was his own insight. An awareness of polysemy and the importance of precise language can also be seen when he weighs whether our understanding of language should be based on the theory of *analogia* or of *anomalia* (*De lingua latina* X.2(6–7), ed. Goetz & Schoell, p. 175):[53]

> *quare quoniam f[u]it, ut potius de vocabulo quam de re controversia esse videatur, illud est potius advertendum, quom simile quid esse dicitur, [quin] cui parti simile dicatur esse (in hoc enim solet esse error), quod potest fieri ut homo homini similis sit, non sit, ut multas partis habeat similis et ideo dici possit similis habere oculos, manus, pedes, sic alias res separatim et una plura. itaque quod diligenter videndum est in verbis, quas partis et quot modis oporteat similis habere, ‹quae similitudinem habere› dicuntur, ut infra apparebit, is locus maxime lubricus est.*
> ‘Because, as it happens that this controversy is rather about words than things, when something is called “similar” it is rather to be discerned to what part [of the other thing] it is similar: for in this the mistake often lies. Just as it may be that one man is similar and not similar to another one, although he has many similar parts and could thus be called similar in having eyes, hands, feet, and other things like this separately or taken together – so it is to be considered exactly in the case of words that are said to be “similar” what parts and in what ways they possess similarly; as will become clear below, this matter is most hazardous.’

Varro ultimately prefers the Aristotelian *analogia* camp over the Stoic anomalists, but rightly insists that the two are both necessary principles for explaining language (IX.1(3), p. 148). Indeed, his argumentation in the above quotation reminds one of Aristotle’s weighing of several meanings of words. Varro speaks about *dis-*

52 See Sallmann (1976).
53 A discussion held mostly between Alexandrian and Pergamon (Greek) scholars, the former claiming that language and grammar are rational, the latter that they are spontaneous products. See Douay & Pinto (1991).

ciplinae right at the beginning of book V of *De lingua latina,* when he discusses the scientific discipline *etymologia*. He often groups words together in a meaningful way; sometimes they are indeed from the same roots (according to modern linguistics), but often the combinations are very fanciful. Much of the surviving books cover *etymologia* in the sense explained above (chap. 1 §9). Occasionally, the author admits that he is not sure about the origin of a word, like (V.36(182), p. 55):

> *stips ab στοιβή fortasse, graeco verbo.*
> 'The word *stips* [donation] maybe derives from the Greek στοιβή [heap].'

He then links many Latin words to this one: *stipare, stipendium, stipulari*. Sometimes he offers more than one explanation (e.g. on *nox*; VI.2(6), p. 59) or refutes an etymology (e.g. of the month name *Aprilis* from Ἀφροδίτη; VI.4(33), p. 70) with convincing arguments. He admits that in the study of poetic language much remains unclear (*latent multa*; VII.1(2), p. 92). That Varro constructed a coherent theory of language is shown by Taylor (1974).

It becomes clear that some technical Latin vocabulary is still not fixed: for instance, Varro usually uses *initium* for ἀρχή, in contrast to later *principium*. In addition, syntactically his prose is sometimes somewhat awkward or (rather) pre-classical.[54] Already for Varro, short relative clauses seem to be the means of choice for translating Greek participles and nominalised verbal expressions, such as *qui soluta oratione loquuntur* ('those who write in prose').[55] Clearly, he felt at least as much at home in Greek as in Latin. Indeed, it seems that he abbreviated three of his long works to a Greek ἐπιτομή (the *Antiquitates*, *Imagines,* and *De lingua latina*). He occasionally gave Latin works Greek titles, such as the *Logistoricon libri,* which apparently contained philosophical dialogues.[56] Varro's long works were often read and digested in late antique compendia, which may partly explain the poor preservation of the original works. Thus, it is but guesswork to tell what content of the later compendia actually goes back to him and what does not. Later

54 As the classicist Norden puts it in Ciceronian pathos: 'Man wird wohl sagen dürfen, daß dies größte Werk über die lateinische Sprache in dem schlechtesten lateinischen Stile geschrieben ist, den irgendein Prosawerk zeigt; im ganzen genommen kann man überhaupt kaum von einem Stil sprechen: es sind roh aufeinander getürmte Steinblöcke' ('It will be fair to say that this greatest work on the Latin language is written in the worst Latin style to be found in any work of prose; on the whole, one can hardly speak of a style at all: there are raw blocks of stone piled up'; 1958: 1:195).

55 *De lingua latina* X.3(70), ed. Goetz & Schoell, p. 188.

56 Fragments in Cardauns (1960).

Latin authors from Antiquity saw Varro as the first, and one of the foremost, Latin scholars. Martianus Capella's *Dialectica* says (IV, §335, ed. Ferré, p. 6) about him:

> *Ni Varronis mei inter Latiares glorias celebrati mihi eruditio industriaque suppeteret, possem, ‹ego›, femina Doricae nationis apud Romuleae uocis examina, aut admodum rudis, aut satis barbara, reperiri. Quippe, post Platonis aureum flumen atque Aristotelicam facultatem, Marci Terentii prima me in Latinam uocem pellexit industria ac fandi possibilitatem per scholas Ausonias comparauit.*
> 'If the erudition and diligence of my famous Varro, the glory among the Latins, had not been at hand, I could have been found a woman of Dorian [i.e. Greek] nation by examination of my Romulian language [i.e. Latin], or even to be either rather uncultured or quite barbarous. Indeed, after Plato's golden flow [of words] and Aristotle's skill, it was Marcus Terentius' diligence which first allured me to the Latin tongue and matched the capabilities of speech at the schools of Ausonia [i.e. Italy].'[57]

Plato is remembered for his rhetoric, Aristotle for his science, Varro for his diligence and for being the founder of Latin dialectic. It is indeed unfortunate that more of his works have not survived.

§6 The Epicurean philosopher Titus Lucretius Carus (ca. 99–ca. 55 BC), about whose life virtually nothing is known, wrote a surviving didactic poem in hexameters, *De rerum natura*. The main point of his poem was to introduce an Epicurean worldview, including Democritus' atomism, to a wider Roman audience. Psychologically, he tries to free people from superstitious fears, indeed from *religio* in general (I.62–89, ed. Ernout, vol. 1, pp. 33–34), a goal he believes can be reached by pondering *naturae species ratioque* (I.148, vol. 1, p. 36). In the first book, he tries to refute the worldviews of Heraclitus, Empedocles, and Anaxagoras. Book II tries to prove an infinite world with many inhabited Earths (II.1048ff., vol. 1, p. 109). Book III sets out to prove the mortality of the soul seen as just a conglomerate of atoms, book V makes plausible how humanity developed culture after starting out as brutes, and book VI explores natural *mirabilia*. Books V and VI in particular do contain scientific arguments, mostly about the Earth and the heavens; but Lucretius' knowledge of these matters is meagre.[58] He makes fun of fancy theories such as a round Earth, with people walking upside down in the antipodes (I.1052–1068, vol. 1, pp. 67–68), even though a spherical Earth had been scientific consensus among the Greeks for centuries by his time.[59] He does make use of syl-

57 Compare chap. 9 §5 below on Martianus and his remarkable Latin.
58 As Stahl (1962: 82) puts it, 'he fails to comprehend the more abstruse doctrines of Epicurus and has an obvious lack of interest in astronomical matters'.
59 Details in Gleede (2021: section 1.1).

logisms, for instance in order to ‘prove’ that his atoms are eternal (I.503–548, vol. 1, pp. 48–50), or in the following (II.479–482, vol. 1, p. 88):

> *[…] primordia rerum*
> *finita variare figurarum ratione.*
> *quod si non ita sit, rursum iam semina quaedam*
> *esse infinito debebunt corporis auctu.*
> ‘[…] that the atoms’ forms vary in a finite way. If it were not so, again some of the atoms would have to exist with infinite size.’

This, however, seems to be more a non sequitur, or maybe a poetic device, not a strictly logical one. Indeed, much of the book is more Epicurean δόξα and an attempt to make converts. Despite this, the author was faced with the difficult task of putting scientific and philosophical Greek thought into Latin, and into Latin that fits hexameters. His vocabulary was studied by Eucken (1879: 50), who composed a list of some of his attempts for new terminology. Some of them did not find widespread imitation: *dispositura, variantia, retinentia, compositura, differtas, formamentum,* while others did: *elementa, experientia, forma, materia/-es, moles, concretus, generalis, innatus*. His language is indeed innovative; in particular, his use of suffixes is striking: *-men, -tus, -cola, -ger, -fer, -tim, -per* are common.[60] For key terms Lucretius used poetic *variatio*, the best example of which is his atoms, which are variously called *principia, semina rerum, corpuscula, minima naturae, rerum primordia, genitalia corpora*; or, in an especially beautiful poetic passage (I.705–715, vol. 1, p. 55), water is described in the space of a few lines as *umor, liquor,* and *imber*. Such poetic synonymy is rather unhelpful for scientific clarity; it is, however, typical for epic language to have several synonyms for important words at one’s disposal for different positions in a line of verse.[61] Lucretius’ poetic language, thus, does not conform well to the scientific needs of *perspicuitas* and *univocitas*.

Lucretius does not usually employ Greek words in his poem, except those that had been imported into Latin by earlier generations (such as *aether, elephantus, lympha, theater*); a rare exception is *philema* (φίλημα; IV.1169, vol. 2, p. 46), ‘kiss’, which is attested in Latin only here. It is interesting to compare how Cicero translated Greek terms. This can most easily be done for Epicurean terms used by both writers, as Peters did.[62] A few examples: Cicero does not mind saying *atomus*, but

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60 List from von Albrecht (1992–1994: 1:238), with bibliographies.

61 Interestingly, the same polysemy can be observed in Indian metrical *śāstra* literature. For the case of astronomy, see Pingree (1981).

62 Peters, *T. Lucretius et M. Cicero*, pp. 6–7. Exact passages are quoted there, but these rare terms can also easily be listed using the lemmatised search function in Corpus Corporum. On p. 24, Peters offers a list of tentative new coinings by both authors.

Lucretius does, and uses many other terms for it, as mentioned. For other terms, too, Lucretius' pursuit of poetic *variatio* becomes clear: Cicero says *inane* for κενόν, Lucretius both *inane* and *vacuum;* Cicero is less scrupulous in coining *indolentia* for ἀπονία, which Lucretius renders as *privatus dolore* (*indolentia* would not fit a hexameter). Some terms had to be circumscribed: φυσιολογία becomes the not very evident *naturae species ratioque* in Lucretius (four times); Cicero has no scruples about using *physiologia,* which, again, cannot fit a hexameter. In a famous, self-conscious passage on his Latinising of Greek concepts, Lucretius writes (I.136–145, vol. 1, pp. 35–36):

> *Nec me animi fallit Graiorum obscura reperta*
> *difficile inlustrare Latinis versibus esse,*
> *multa novis verbis praesertim cum sit agendum*
> *propter egestatem linguae et rerum novitatem;*
> *sed tua me virtus tamen et sperata voluptas*
> *suavis amicitiae quemvis efferre laborem*
> *suadet et inducit noctes vigilare serenas*
> *quaerentem dictis quibus et quo carmine demum*
> *clara tuae possim praepandere lumina menti,*
> *res quibus occultas penitus convisere possis.*
>
> 'It is not hidden to me that it is difficult to explain the obscure discoveries of the Greeks in Latin verses, especially as one has to deal with many things in new words because of the poverty of the [Latin] language and the novelty of the content. But your[63] virtue and the expected sweet joy of your friendship persuade me to tackle any toil and make me wake through cheerful nights and seek with what words and what song I might unveil the clear light of your mind, with which you are able to examine hidden things fully.'

The apparent *egestas* of Latin is mentioned again in III.260, vol. 1, p. 124, as an excuse for why the author cannot explain how the atoms mix to form larger bodies. In fact, this would rather seem to be due to missing fundamentals of physics and chemistry than a matter of language. Of course, Lucretius cannot be blamed for not being a modern chemist (Lavoisier's kind of chemistry was developed nineteen centuries after him), but this passage makes one suspect that the *egestas* quoted above may also be more of an excuse than a genuinely felt deficiency.[64]

Both his approach (atheism, atoms and void, infinite worlds, mortality of the soul) and his language will find imitation in early modern times, most conspicu-

63 The poet is speaking to Venus, the deity of *voluptas*, the Epicurean goal in life.

64 More on this in Fögen (2000: 228); this topos is most often repeated in the context of *Fachsprache*, and the poverty is mostly seen in the lexicon. But Fögen's sweeping conclusion that 'Sprache, Rasse, Nationalcharakter und Kultur nichts miteinander zu tun haben' ('language, race, national character, and culture have nothing to do with each other'; 235) is a non sequitur.

ously by Giordano Bruno (see chap. 12 §4), but his style, including its poetic *variatio* in the designation of key terms, will become the general norm for didactic poets in general. For instance, Benedictus Stay – writing hexametric poetry about Newtonian physics in the eighteenth century – still uses *munus, officium, vires* all to mean physical 'property' with no semantic distinction.[65]

§7 Marcus Tullius Cicero's (106–43 BC) important rôle in the creation of Latin technical as well as rhetorical language is generally acknowledged.[66] He was first and foremost a politician and orator; his interest in Greek science was limited, and his interest in Greek philosophy had a typically Roman practical bent, as he himself states (*Tusculanae disputationes* I.2(5), ed. Fohlen, p. 6):

> *In summo apud illos honore geometria fuit, itaque nihil mathematicis inlustrius; at nos metiendi ratiocinandique utilitate huius artis terminavimus modum.*
> 'Geometry stood in highest esteem among them [the Greeks], and so nothing was more famous than the mathematicians, but we [the Romans] limited the manner of this art to the utility of measuring and reckoning.'

Which is, in fact, what the Egyptians had already done before the Greeks. A little later (I.4(7), p. 7) he points out:

> *perfectam philosophiam semper iudicavi, quae de maximis quaestionibus copiose posset ornateque dicere.*
> 'I always judged the best philosophy to be the one that is able to speak copiously and ornately about the highest questions.'

Of course, for 'copious and ornate' speaking, one does not necessarily have to understand the topic at hand fully. Indeed, Cicero admits his difficulty in understanding higher Greek learning and shows a lack of interest in trying harder. He gave up his project of writing a study on geography, as he confesses to Atticus (*Ad Atticum* II.4.1, ed. Watt, p. 53):

> *Fecisti mihi pergratum quod Serapionis librum ad me misisti; ex quo quidem ego, quod inter nos liceat dicere, millesimam partem vix intellego.*
> 'You made me a great favour by sending me Serapion's book, of which, as I may say between us, I hardly understand a thousandth part.'

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65 In his *Philosophiae recentioris versibus traditae.* I.409 makes this amply clear: *Ast hic officia, aut vires, aut munera dicam* ('But I will say property, force, or function').

66 The literature on Cicero is too vast to do it justice here. We mostly quote directly from his works. Büchner (1964) is still worth reading on his life and work.

Thus, Cicero was not deeply interested in Greek natural science, but his interest and skill in political and social science (as we would call it today) was considerable.[67] His most ambitious work may be the dialogue *De re publica*, which imitates Plato's *Respublica* in form, but its content is quite original. It survives only, and not in full, on a palimpsest (fig. 11). Cicero stresses that he agrees with Socrates, who instead of studying nature cared more about things relevant to human life (*De re publica* I.10(15), ed. Ziegler, p. 11), concluding that *eas artis, quae efficiant, ut usui civitati simus* ('those arts that make us useful to the state'; I.20(33), p. 22) are the most important ones. He stresses the importance of properly defining the matters one studies (I.24(38), p. 24) and that rational argument is more important than authority (I.38(59), p. 36). The dialogue's setting is in a villa at a gathering of Scipio Africanus the Younger and some of his friends, because (III.3 (5), pp. 83–84)

> *ad domesticum maiorumque morem etiam hanc a Socrate adventiciam doctrinam adhibuerunt.*
> 'it was them who added the teaching originating from Socrates to [Roman] home-grown custom from the forefathers'.

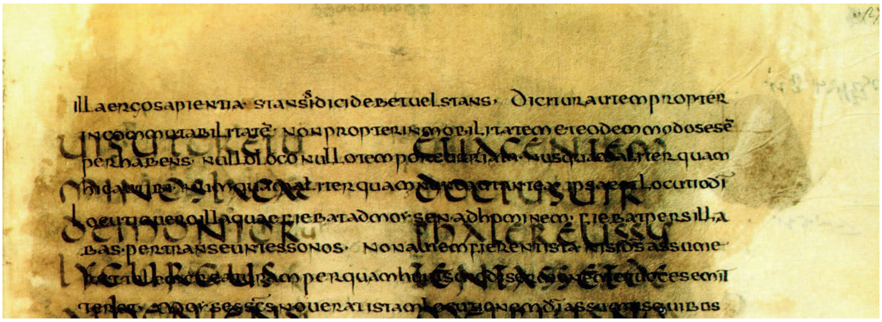

Fig. 11: Cicero's *De re publica* (here parts of II.1), which survives only on a palimpsest (ca. AD 400). Roma, Biblioteca Apostolica Vaticana, Vat. lat. 5757, p. 277. The text written over it is Augustine, *Ennarrationes in Psalmos*.
Source: https://commons.wikimedia.org/wiki/File:Cicero,_De_re_publica,_Vat._Lat._5757.jpg (image by user Πυλαιμένης, public domain).

Much of book II contains examples of state forms that are evaluated to determine which one is best. In some points, Cicero differs strongly from Plato: for example, in IV.4(4), p. 109, he disapproves of pederasty. His search for the optimal state is

67 See Wood (1988) on the importance of Cicero's political thought.

in general much more realistic than Plato's, and may be called a scientific contribution to politology.[68]

Cicero himself sees one of his greatest contributions in having made the Latin language richer (*Brutus* 72(253), ed. Martha, p. 91):

> *[...] cuius te paene principem copiae atque inventorem bene de nomine ac dignitate populi Romani meritum esse existimare debemus.*
> '[Atticus speaking about Cicero:] in which we have to value your merit highly for the name and dignity of the Roman people as almost the pioneer and bringer of wealth [of language and eloquence].'

In order to do this, he faced a similar problem to Lucretius: he wanted to integrate Greek concepts into normal Latin, although for rhetorical instead of poetical reasons.[69] Indeed, he tried to prove that Latin can express everything Greek can (*De finibus* III.1(5), ed. Moreschini, p. 91):

> *[...] nos non modo non vinci a Graecis verborum copia, sed esse in ea etiam superiores,*
> '[...] that we are not only not vanquished by the Greeks at the amount of words, but we are even better at it',

since he thinks (I.10, p. 5):

> *Latinam linguam non modo non inopem, ut vulgo putarent, sed locupletiorem etiam esse quam Graecam.*
> 'The Latin language is not only not poor, as the crowd thinks, but richer even than the Greek.'

Nonetheless, he is aware that this is quite wishful thinking, as he betrays in *Tusculanae* (II.15(35), ed. Fohlen, p. 96):

> *Haec duo Graeci illi, quorum copiosior est lingua quam nostra, uno nomine appellant.*
> 'The Greeks call these two [words, i.e. *dolor* and *labor* = Greek πόνος] by the same name, although their language is richer than ours.'

His success in improving Latin's richness of expression was limited, but Cicero's Latin style was to become a rôle model in many prose genres. Cicero is also often credited with the idea of building a native Latin philosophical language instead of

68 Cicero's abilities in this respect were seen very negatively by Montesquieu, Hegel, and Mommsen, often citing character deficits in Cicero. But Bernett (1995) rightly revises this excessively negative assessment (5–6 on these three authors, 260–265 for her own assessment).
69 See Michel (1972–1973).

merely imitating Greek.[70] He is not afraid to use new words in general (*De finibus* III.4(15), ed. Moreschini, p. 95):

> *Si enim Zenoni licuit, cum rem aliquam invenisset inusitatam, inauditum quoque ei rei nomen inponere, cur non liceat Catoni? Nec tamen exprimi verbum e verbo necesse erit, ut interpretes indiserti solent, cum sit verbum, quod idem declaret, magis usitatum. Equidem soleo etiam quod uno Graeci, si aliter non possum, idem pluribus verbis exponere, et tamen puto concedi nobis oportere ut Graeco verbo utamur, si quando minus occurret Latinum, ne hoc 'ephippiis' et 'acratophoris' potius quam 'proegmenis' et 'apoproegmenis' concedatur; quamquam haec quidem 'praeposita' recte et 'reiecta' dicere licebit.*
> 'If it was permitted to Zeno, when he encountered an unusual matter, to impose an unheard-of name onto it, why should this not be permitted to Cato? Yet it would not be necessary to translate it word by word, as translators lacking eloquence are wont to, if a synonymous word is more usual. Indeed, it is also my custom to express in several words what is expressed in one Greek word, if it cannot be helped. And yet I hold that it must be allowed us to use a Greek word if ever a [corresponding] Latin word occurs less, so that *ephippia* [saddle] or *acratophora* [wine-cup for unmixed wine] should be more acceptable than *proëgmena* or *apoproëgmena*, as the latter can be said as *praeposita* [preferred] and *reiecta* [rejected].'

Incidentally, Cicero here also tells us about bad translators of Greek philosophy in his time. Of course, he also keeps using Greek words that are already in firm use in Rome such as *philosophia*, *grammatica,* or *musica*: *quamquam latine ea dici poterant* ('although they could be said in Latin'; III.5, p. 91). Cicero states (*Academica* I.7(25), ed. Plasberg, p. 47):

> *et id quidem commune omnium fere est artium; aut enim noua sunt rerum nouarum facienda nomina aut ex aliis transferenda. quod si Graeci faciunt, qui in his rebus tot iam saecla versantur, quanto id nobis magis concedendum est, qui haec nunc primum tractare conamur.*
> 'and this is common to almost all *artes*: either new names have to be coined for new matters, or they have to be transferred from other [fields]. If the Greeks, who have been engaged in these matters already for centuries, do this, how much more this has to be conceded to us who are now for the first time trying to practise them.'

Nevertheless, on the whole Cicero tries to avoid neologisms and uses existing words for new Greek concepts[71] – similarly to what Aristotle already did in Greek. A few examples of his translations (it is not always clear whether they really are new coinings or not): *decorum* (for τὸ πρέπον), *mulierositas* (φιλογύνεια), *orbis* (κύκ-

70 See Levy (1992), and also Poncelet (1957) and Puelma (1980), who agree on this topic.
71 Glucker (2012) collects the passages where Cicero discusses his translations of philosophical terms.

λος), *providentia* (πρόνοια), *qualitas* (ποιότης), *temperantia* (σωφροσύνη).[72] Springhetti points out (*Latinitatis fontium*, p. 20):

> *Ut statim apparet, haec vocabula fere ex philosophia Stoicorum et Epicureorum desumpta sunt; ex Aristotele vero quaedam mutuavit de re dialectica et rhetorica. Nihil prope invenitur in Cicerone de vocabulis propriis investigationis metaphysicae et logicae, hoc est de 'ente' et 'essentia', de cognitionis ratione, etc., quae in Aristotele et apud cultores philosophiae 'scholasticae' inveniuntur.*
> 'As becomes immediately clear, these words are usually taken from Stoic and Epicurean philosophy; from Aristotle he borrowed some concerning dialectic and rhetoric. But close to nothing is found in Cicero concerning proper terms of metaphysical or logical investigation, that is, "being" and "essence", or epistemology, etc., which are found in Aristotle and in scholastic philosophers.'

For Epicurean concepts, he coins abstract terms by suffixation, such as *adhaesio* (ἁφή), *aequilibritas* (ἰσονομία), *contemplatio* (θεωρία), *perspicuitas* (ἐνάργεια), *titillatio* (γαργαλισμός)[73] – exactly what humanist Ciceronians will blame 'scholastics' for. It has already been pointed out that Cicero cared more about rhetoric than about scientific knowledge; this explains his approach to new coinings very well: the *rhetor* should use unusual words sparingly in order not to put off his audience.[74] However, in his private correspondence, when he is not hard-pressed by his project of proving Latin's capabilities, things look somewhat different. An example will show how Cicero is in colloquial speech quite unable to resist the use of Greek philosophical and other terms (*Epistula ad familiares* XV.18, ed. Shackleton Bailey, p. 575):

> *longior epistula fuisset, nisi eo ipso tempore petita esset a me, cum iam iretur ad te; longior autem φλύαρον aliquem habuisset nam σπουδάζειν sine periculo vix possumus.*
> 'The letter would be longer if it had not been requested from me [by the messenger] who was leaving for you. But it would have been longer containing *foolery*, for we can hardly *be serious* without danger.'

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72 See the long list in Springhetti, *Latinitas fontium*, pp. 15–20. More examples from Eucken (1879: 52): *affectio, anticipatio, complementum, differentia, distantia, evidentia, impressio, incrementum, inductio* (technically), *lineamentum, notio, partitio* vs *divisio, progressio, proportio, propositio, proprietas, qualitas, relatio* (only as rhetorical concept), *varietas, definitivus, disparatus, dividuus* vs *individuus, moralis, nativus, modificare*.

73 See Peters, *T. Lucretius et M. Cicero*, who provides a long list. Loci can be easily found in Corpus Corporum.

74 As Cicero himself explains in *De oratore* III.154, ed. Kumaniecki, pp. 321–322, with two examples.

Greek terms are italicised in the translation. But an answer by his friend Gaius Cassius Longus shows how far Roman intellectuals could go in mixing languages (XV.19, p. 576):

> *difficile est enim persuadere hominibus τὸ καλὸν δι' αὑτὸ αἱρετὸν esse; ἡδονὴν vero et ἀτ‹αρ›αξίαν virtute, iustitia, τῷ καλῷ parari et verum et probabile est. ipse enim Epicurus, a quo omnes Catii et Amafinii, mali verborum interpretes, proficiscuntur, dicit 'οὐκ ἔστιν ἡδέως ἄνευ τοῦ καλῶς καὶ δικαίως ζῆν.' itaque et Pansa, qui ἡδονὴν sequitur, virtutem retinet, et ii qui a vobis φιλήδονοι vocantur sunt φιλόκαλοι et φιλοδίκαιοι omnisque virtutes et colunt et retinent.*
> 'For it is difficult to persuade men that *the good* is *to be preferred for its own sake*; it is both true and demonstrable that *pleasure* and *impassiveness* prepare virtue, justice, and *the good*. For Epicurus himself, from whom all Catii and Amafinii – bad translators of his words – set out, says: *there is no pleasurable life without a good and just one*. Therefore, also Pansa who follows *pleasure*, maintains virtue, and those whom you call *pleasure-lovers* are *lovers of the good* and *the just* and cultivate and maintain all virtue.'

In his works for publication, Cicero clearly constrains himself to using purer Latin style, which he was thus to shape decisively. It will be seen that Cicero's influence on technical language is rather less decisive than that on Latin in general. This is not surprising: forms of Latin with fewer rhetorical constraints were found to be more useful for scientific communication. Nonetheless, we should not underestimate the pioneering effort of Cicero, which certainly did have an impact on the further emancipation of Latin from Greek.

The slightly earlier, anonymous author of the *Rhetorica ad Herennium* (ca. 86–82 BC) – met above as the first attested user of the word *scientia* (chap. 2 §3) – must be mentioned here, at least in passing, for forging a Latin terminology for Greek rhetoric.[75] He believes that ὀνοματοποιεῖν, *nova verba fingere* ('coining new words'), is only acceptable in poetry (IV.42, ed. Achard, p. 182), a sentiment that seems to hold good for much of Latin literature and rather to the detriment of scientific expression.

The most important technical writer in this epoch from whom there is an extant text is certainly Marcus Vitruvius Pollio (ca. 75–ca. 15 BC). He had worked as an imperial engineer constructing war-engines, bridges, basilicas, and aqueducts. His treatise on architecture and engineering – finished only in the 20s[76] – endeavours to be more than a practical *artes* handbook, as the very beginning makes clear (*De architectura* I.1.1, ed. Fensterbusch, p. 22):

75 Examples of terms in Eucken (1879: 51).
76 See von Albrecht (1992–1994: 1:695).

> *Architecti est scientia pluribus disciplinis et variis eruditionibus ornata, cuius iudicio probantur omnia quae ab ceteris artibus perficiuntur opera. Ea nascitur ex fabrica et ratiocinatione.*
> 'The knowledge of an architect is adorned with many sciences and various kinds of learning. By his judgement everything accomplished by the other arts is examined. This knowledge arises from both practice and theory.'[77]

He also stresses that all sciences form a single edifice (I.1.12, p. 30):

> *At fortasse mirum videbitur inperitis, hominis posse naturam tantum numerum doctrinarum perdiscere et memoria continere. Cum autem animadverterint omnes disciplinas inter se coniunctionem rerum et communicationem habere, fieri posse faciliter credent; encyclios enim disciplina uti corpus unum ex his membris est composita.*
> 'It may seem amazing to those unacquainted [with science] that human nature is able to learn thoroughly such a number of teachings and to keep them in memory. But when they realise that all sciences are conjoined and in communication among each other, they will easily believe that it is possible. The cycle of the sciences is made up as if one body from such members.'

In contrast to Cicero, Vitruvius' language appears relatively plain, but the author is nonetheless certainly consciously adorning it rhetorically. The eighteenth-century criticism of *Schusterstil* ('cobbler style') is certainly manqué.[78] The composition is well structured, and every book has a preface situating its content in the work. Unfortunately, the technical designs that were included have been lost. The book became very influential among Renaissance architects.

Although both the Roman epoch and the Early Middle Ages saw few advances in the more theoretical sciences in Latin, technical knowledge grew steadily through the entire period (Hägermann & Schneider 1991: 244):

> Neuerungen wie das gallische Mähgerät oder der Räderpflug machen deutlich, daß die Römer überdies fähig gewesen sind, auf veränderte regionale Bedingungen zu reagieren. Angesichts solcher Fakten muß dem Imperium Romanum eine hohe Dynamik technischer Entfaltung zuerkannt werden.
> 'Innovations such as the Gallic mower or the wheeled plough show that the Romans were furthermore able to respond to various regional conditions. In the light of these facts, the Roman Empire must be recognised as having been highly dynamic in its technological development.'

Unfortunately, but few technical treatises like Vitruvius' have come down to us. Frontinus (ca. 40–103), the author of another such text, in good Roman vein

77 Vitruvius seems to try to take πρακτική and θεωρετική over into Latin with *fabrica* and *ratiocinatio*.
78 Loci in von Albrecht (1992–1994: 1:700).

points out the importance of useful technical engineering (*De aquis* 16, ed. Kunderewicz, p. 11):

> *Tot aquarum tam multis necessariis molibus pyramidas videlicet otiosas conpares aut cetera inertia sed fama celebrata opera Graecorum!*
> ‘Compare, if you will, with these massive [Roman] water-conducting constructions, useful to many, the idle pyramids or other useless but celebrated works of the Greeks!’

Later imperial era

§8 A selection of some potentially ‘scientific’ imperial authors is now considered. The medical writer and pioneer in medical Latin Cornelius Celsus (ca. 25 BC–ca. AD 50) and his language will be discussed below (chap. 21 §3). Much remains unclear about the anonymous hexametric didactic poem *Aetna*. Sudhaus, its editor, sees it in early Augustan times, von Albrecht (1992–1994: 1:564) rather in the first century AD. It was certainly written before the great eruption of Vesuvius in AD 79, which would hardly have gone unmentioned. The author’s diction is clearly indebted to Lucretius;[79] much of his content is probably based on lost Greek works by Posidonius. His language is full of metaphors and allusions and often difficult to follow.[80] The text studies in a Stoic manner θαυμάσια τῆς γῆς (‘marvels of the Earth’), in this case the greatest known volcano. About two-thirds of the 646 lines treat volcanism in a scientific manner (the rest is *prooemium* and *conclusio,* much of which are directed against the mythological ‘lies’ of poets).[81] The poet’s ardour for science can be seen in the following lines, in a single sentence spanning twenty-eight lines (*Aetna* 224–251, ed. Sudhaus, pp. 16–18):

> *Non oculis solum pecudum miranda tueri*
> *more, nec effusos in humum grave pascere corpus,*
> *nosse fidem rerum dubiasque exquirere causas,*

79 See Sudhaus’s edition, p. 82, for details.

80 Sudhaus in his edition characterises the author’s language thus: ‘seine Abhängigkeit von dem Ausdruck seiner lateinischen Vorgänger und seines unzweifelhaft griechischen Originals, das Ringen mit einem schwierigen und der poetischen Bearbeitung widerstrebenden Stoffe, der von dichterischer Seite vorher nicht durchgearbeitet war, das Schwelgen in Metaphern und Personifikationen, vielleicht auch das unbeabsichtigte Einfliessen einzelner Worte und Wendungen eines *sermo plebeius* – alles das hat dazu beigetragen, unser Gedicht zu einem der schwierigsten zu machen’ (‘his dependence on the expression of his Latin predecessors and his unquestionably Greek original, his wrestling with a difficult subject matter that resisted poetic adaptation and that had not previously been elaborated by poets, his indulgence in metaphors and personifications, perhaps also his unintentional inclusion of individual words and phrases of a *sermo plebeius* – all this contributed to making our poem one of the most difficult’; p. vi).

81 On its content and poetology, see Volk (2005).

> *ingenium sacrare caputque attollere caelo,*
> *scire quot et quae sint magno natalia mundo*
> *principia [...]*
> *sed manifesta notis certa disponere sede*
> *singula, divina est animi ac iucunda voluptas.*
>
> 'Not to see with the eyes alone the wonders [of the world] as cattle do, nor to be fixed to the soil and to fatten the heavy body, but to know what is the nature of things and to seek out as yet uncertain causes, to consecrate one's mind and to raise one's head to the sky, to know how many and what are the inborn principles of the great world, [examples of scientific questions follow], but to assign to each single phenomenon its certain place – that is divine and delightful joy for the mind.'

This little poem has only survived because it was included in the *Appendix Vergiliana*, which can serve as a reminder of how much more scientific material will have existed of which no knowledge whatsoever has come down to us. No conclusion has been reached as to the relationship (if any) between *Aetna* and Seneca, the next author. In general, this remarkable scientific poem enjoyed little success.

Lucius Annaeus Seneca (4 BC–AD 65)[82] is another Roman author who may be labelled a scientist. As a Stoic gentleman philosopher, he was mostly interested in ethics, and most of his extant work deals with ethical questions, but it is known that in his youth he followed scientific interests, possibly acquired during his stay at Alexandria, and he wrote works such as *De situ et sacris Aegyptiorum, De situ Indiae, De lapidum natura, De piscium natura, and De forma mundi*. Unfortunately, they are completely lost.[83] He describes his methodology, applicable both to literary studies and to scientific ones, in *Epistola* 84 (2–7, ed. Préchac, vol. 4, pp. 121–123), likening the work to bees who collect material but transform (*concoquere*) what is collected into something new. The surviving work most promising for our purposes is the *Naturales quaestiones*. It treats striking phenomena from the natural world in eight books, especially atmospheric phenomena, the flow of water (especially the Nile), wind, earthquakes, and comets. Surprisingly, volcanoes are absent. The author states his aim as (III, praef. 1.1, ed. Hine, pp. 108–109):

> *mundum circuire constitui et causas secretaque eius eruere atque aliis noscenda prodere.*
> 'I decided to survey the world in order to dig up its causes and secrets and to disclose what is known to others.'

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82 Grimal (1979) is recommended as an introduction to this well-studied and important author.

83 Von Albrecht (1992–1994: 1:930). More details in Berno (2015: 82). Cassiodorus still read a *De forma mundi*. Grimal (1979: 66–78) covers Seneca's time in Alexandria.

Seneca relies heavily on Aristotle and Posidonius, the extent of the latter's use being hard to gauge as his works are lost. Oltramare, in his edition of the *Quaestiones,* discusses whether Seneca's work should be termed 'scientific' and answers in the affirmative, among other things because of Seneca's approval of the beauty of disinterested science,[84] because he leaves unclear questions undecided,[85] and because he believes in science's progress and admits that some scientific problems need further study (esp. *Naturales quaestiones* VII.3, ed. Hine, pp. 284–285: comets). But Oltramare also admits that the work is not a strict scientific or technical work: the author uses changing terminology (e.g. *spiritus* and *anima* can mean very different things), and the work has literary pretensions (edition, p. xxxiii). Besides, there are hardly any observations and conclusions that are without doubt first-hand. An example of Seneca's way of reporting science is the genesis of lightning (II.21.1, p. 71). Seneca states:

> *Dimissis nunc praeceptoribus nostris incipimus per nos moueri, et a confessis transimus ad dubia. quid in confesso est? fulmen ignem esse, aeque fulgurationem, quae nil aliud est quam flamma futura fulmen si plus uirium habuisset; non natura ista sed impetu distant.*
> 'After our teachers have been heard, let us begin to move by ourselves and pass over from what is clear to the uncertain. What is clear? That lightning is fire, and similarly sheet lightning, which is nothing else than a flame that would become lightning if it had more force. They do not differ in nature, only in intensity.'

Seneca then explains that lightning is generated by colliding clouds – a theory he sells as his own, but which is by and large Aristotelian (*Meteorologica* II.9). The argumentation is based on analogies and probabilities from better-known phenomena (striking fire through friction or hitting violently; *Naturales quaestiones* II.22.1, ed. Hine, pp. 72–73) to the *explicanda*. In the manner of question-and-answer literature, he also addresses counterarguments. The procedure is quite as scientific as was then possible, although the work is clearly written not for 'scientists' but for educated laymen and may be called a handbook of striking natural phenomena. Perhaps most remarkably, in book VII, on comets, Seneca rightly argues that comets are regular supra-lunar phenomena, a point on which Galileo still went badly astray, believing them to be atmospheric in nature and polemicising against the Jesuit Orazio Grassi, who held the correct point of view.[86]

84 e.g. '*Quod' inquis 'erit pretium operae?' quo nullum maius est, nosse naturam* ('"What", you will ask, "is the value of the work?" That compared to which there is none greater: to know nature'; *Naturales quaestiones* VI.4.2, ed. Hine, p. 238).
85 *Interim illud existimo [...]* ('For the time being, I hold this [...]'; I.1.5, p. 155).
86 Cf. Galileo's *Discorso delle comete* (Galilei 2005). The question was much discussed in the seventeenth century.

Although Seneca admits taking this point over from an otherwise unknown and undatable Apollonius of Myndus (VII.4.1, p. 285) – who apparently claimed to follow some *Chaldaei* – he nonetheless tries to refute his main sources, Posidonius and Aristotle, and he emphasises how little is still known about such a rare phenomenon as comets (VII.3.1, pp. 284–285):

> *Necessarium est autem ueteres ortus cometarum habere collectos. deprendi enim propter raritatem cursus eorum adhuc non potest, nec explorari an uices seruent et illos ad suum diem certus ordo producat. noua haec caelestium obseruatio est et nuper in Graeciam inuecta.*[87]
> 'It is necessary to have collected past appearances of comets. Their orbits could not yet be detected due to their rarity, nor could it be elucidated whether they are subject to return and that a fixed order produces them on the right day. Such observation of heavenly phenomena is still young and was only recently introduced into Greece.'

The *Naturales quaestiones* seem to have been a rare work before the twelfth century, but there are many manuscripts from that century, and some one hundred in total,[88] showing that it was much read in the early times of the heyday of mediaeval science (although possibly as yet *faute de mieux*); it was still much admired by Roger Bacon.[89]

Seneca discusses the rôle of Latin and Greek in a few interesting passages in his letters. He lives roughly a century after Cicero, but the situation does not seem to have changed much in respect to the general approach to new coinings and to the perceived or topical inferiority of Latin compared to Greek. His well-known discussion of the participle of 'to be' (*Epistola* 58.1, 6.7, ed. Préchac, vol. 2, pp. 70–71):

> *Quanta uerborum nobis paupertas, immo egestas sit, numquam magis quam hodierno die intellexi. Mille res inciderunt, cum forte de Platone loqueremur, quae nomina desiderarent nec haberent, quaedam uero ‹quae› cum habuissent, fastidio nostro perdidissent. Quis autem ferat in egestate fastidium? [...]*
> *'Quid sibi, inquis, ista praeparatio uult? Quo spectat?' Non celabo te: cupio, si fieri potest, propitiis auribus tuis "essentiam" dicere; si minus, dicam et iratis. Ciceronem auctorem huius uerbi habeo, puto locupletem: si recentiorem quaeris, Fabianum, disertum et elegantem, orationis*

87 Seneca, remarkably, goes on to prophesy Halley's achievement (VII.25.7, p. 312): *Erit qui demonstret aliquando in quibus cometae partibus currant, cur tam seducti a ceteris errent, quanti qualesque sint. Contenti simus inuentis: aliquid ueritati et posteri conferant* ('There will be someone who at some point will demonstrate in what part [of the world] comets run, why they err so far off the other [planets], how many and what kinds there are. Let us be content with what we have found; let posterity confer something to truth too').

88 See the edition by Hine, pp. vi–xx.

89 There are 120 mentions of Seneca's name in the *Opus maius* alone.

etiam ad nostrum fastidium nitidae. Quid enim fiet, mi Lucili? Quomodo dicetur οὐσία[90] *res necessaria, natura continens fundamentum omnium? Rogo itaque permittas mihi hoc uerbo uti. Nihilominus dabo operam, ut ius a te datum parcissime exerceam: fortasse contentus ero mihi licere. Quid proderit facilitas tua, cum ecce id nullo modo Latine exprimere possim, propter quod linguae nostrae conuicium feci? Magis damnabis angustias Romanas, si scieris unam syllabam esse, quam mutare non possum. Quae sit haec, quaeris? τὸ ὄν.*
'How great is the poverty of our vocabulary, even insufficiency, I have never better understood than today. We come across a thousand things, for instance when speaking about Plato, that should have a name but do not. Some, that would have had one, lost it due to our haughtiness. Who can stand haughtiness in insufficiency? [...]
"What is this preface for?", you will ask, "Whereto does it aim?" I shall not conceal it from you: I wish, if it may be, to say *essentia* to your well-disposed ears. If not, I shall say it to angry ears. I have Cicero as the authority of this word, I daresay a substantial one. If you want a more recent one, Fabianus, an educated and elegant author of a polished speech even for our haughtiness. For what could be done, my Lucilius? How could οὐσία be said, the necessary thing which naturally contains the foundation of all things? I ask you to allow me to use that word. Nonetheless, I will strive to use the concession you gave me but very sparingly; possibly, I shall even be content to have it. But to what avail will your readiness be, when I can in no way express in the Latin language what made me raise this outcry against our language? You would even more damn the Roman narrowness, if you knew that it is a single syllable that I cannot translate. You will ask, which one is this? τὸ ὄν [being].'

In fact, already Caesar had proposed to fill this gap in the conjugation of the verb *esse*,[91] which is especially painful to philosophers, with a new word *ens* by analogy with *potens*.[92] Only in Late Antiquity did the word become common in philosophical literature. Seneca also realised that words tend in general not to be used without ambiguity (*De beneficiis* II.34, ed. Préchac, p. 58):

plures esse res quam uerba. Ingens copia est rerum sine nomine, quas non propriis appellationibus notamus, sed alienis commodatisque.
'there are more things than words. There are a tremendous amount of things without a name, which we do not call by their proper appellation but by alien and adapted ones.'

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90 According to Quintilian, the Stoic Sergius Plautus translated this word as *essentia*: *οὐσίαν, quam Plautus essentiam vocat, neque sane aliud est eius nomen Latinum* ('οὐσία, which Plautus calls *essentia*, as forsooth there is no other name in Latin'; *Institutio oratoria* III.6.23, ed. Rahn, vol. 1, p. 316). Details in Fögen (2000: 162).

91 As quoted in Priscian, *Ars* XVIII.75, ed. Hertz, vol. 2, p. 239.

92 From a modern linguistic point of view, **sens* would have been preferable (compare *absens*, *praesens*). The old participle of *esse* was lexicalised as *sons* ('guilty', the one who 'was' it). For more on *ens*, see Stotz (1996–2004: VIII, §127.5 = vol. 4, p. 221).

In his letters, he often discusses the precise meaning of Latin terms and their relation to Greek ones.[93] But, as we have seen, he does not seem to use them more unambiguously in his *Naturales quaestiones*. In general, his aristocratic manners apparently made him less interested in scientific strictness and painstaking gathering of data. He is more concerned with pursuing what Norden nicely characterised as 'das Ungewöhnliche, Packende, ja Raffinierte durch Zusammendrängung langer Gedankenreihen in sensationelle Pointen' ('the unusual, enthralling, refined, by compressing long lines of thoughts into sensational points'; 1958: 1:319). Seneca was, of course, able to write very different kinds of Latin. His only surviving scientific work mixes rather terse scientific prose, often including series of logical arguments, with Stoic rhetorical exuberance.[94]

§9 Marcus Fabius Quintilianus' (ca. 35–ca. 100) only extant work, the *Institutio oratoria,* is concerned with mostly practical rhetoric and can therefore hardly qualify as a scientific text. But it is nonetheless a very well-structured handbook that studies many facets of language in a scientific spirit. The topic is the *ars oratoria*. Similarly to what Vitruvius had pointed out for the art of the architect, in order to be a good orator one must know the sciences (*Institutio oratoria* I, praef. 18–19, ed. Rahn, vol. 1, p. 10):

> *Sit igitur orator vir talis, qualis vere sapiens appellari possit; nec moribus modo perfectus [...] sed etiam scientia et omni facultate dicendi. qualis fortasse nemo adhuc fuerit.*
> 'The orator should thus be such a man as can be called truly wise: not only perfect in his manners [...] but also in knowledge and in all ways of speaking. Maybe no one has as yet been such a one.'

His point about the potential of the Latin language is interesting: he is afraid that Latin is losing words (VIII.6.32, vol. 2, p. 230):

> *deinde, tanquam consumpta sint omnia, nihil generare audemus ipsi, cum multa cotidie ab antiquis ficta moriantur.*
> 'Then, as if all possibilities had been used up, we do not dare to create new ones, although every day many coinings of the ancients vanish.'

And he, again, emphasises Latin's poverty (VIII.3.33, vol. 2, p. 162):

93 See Grimal (1992), who studied his use of the terms for 'mind' in Latin.
94 On the style of the *Naturales quaestiones,* see Berno (2015: 90).

> *multa ex Graeco format nova ac plurima a Verginio Flavo, quorum dura quaedam admodum videntur, ut queens*[95] *et essentia; quae cur tantopere aspernemur nihil video, nisi quod iniqui iudices adversus nos sumus ideoque paupertate sermonis laboramus. quaedam tamen perdurant.*
> 'Many new coinings are imitated from Greek, especially many by Verginius Flavus,[96] of which some are rather harsh, such as *queens* or *essentia*. I do not understand why we disdain them so much, unless we are ill-disposed judges against ourselves and toil for the poverty of our own language. But some of them do survive.'

He quotes some such words that had only recently been admitted as decent Latin: *reatus, piratica, musica, fabrica*. Quintilian emphasises the importance of scientific progress and laments that it is not of great importance to his contemporaries (X.2.4–5, vol. 2, p. 486):

> *Ante omnia igitur imitatio per se ipsa non sufficit, vel quia pigri est ingenii contentum esse iis, quae sint ab aliis inventa. quid enim futurum erat temporibus illis, quae sine exemplo fuerunt, si homines nihil, nisi quod iam cognovissent, faciendum sibi aut cogitandum putassent? nempe nihil fuisset inventum. cur igitur nefas est reperiri aliquid a nobis, quod ante non fuerit?*
> 'Most of all, imitation by itself is thus not sufficient; indeed, it is typical of a slothful mind to be content with what others have invented. What future could there have been in those times that lacked examples if men had held that nothing except what was already known was to be done or thought? Obviously, nothing would have been invented. Therefore, why is it unseemly that something should be found by us that had not been known before?'

The Roman rhetorical taste had hardly changed since Cicero's time; novelty was still seen as a vice.

Among all of the authors mentioned up to now, there is a tendency not to coin new words but rather to restrict or otherwise change the scope of existing words, as will be confirmed in more detail below (chap. 21) for the medical writer Celsus. We saw above that some Greek authors (such as Plato and to a lesser degree Aristotle) used the same kind of caution when in need of new terminology, but some did not mind new words at all (such as Democritus). The following authors are more practically minded and more open to acquiring new terminology, and less

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95 An unusual participle to the defective verb *queo*. The manuscripts have the meaningless *quae ens;* the reading *queens* is based on a modern emendation by Halm which the editor Rahn does not accept. But the rare occurrence of the similar form *quiens* (twice in Apuleius) and the absence of *ens* in these early times makes it plausible. Rahn reads, less convincingly, *[quae] ens*, having erroneously taken up *quae* from the clause immediately following. Leumann (1977: 521–522) also reads *queens*.

96 Author of a lost *Ars rhetorica* under Nero.

bound by a Latin stylistic ideal, be it for coining new words or even for using foreign (i.e. Greek) words.

§10 Gaius Secundus Plinius (AD 23–79) wrote a large, surviving encyclopaedia of 'natural history'.[97] Like Seneca, Pliny was an aristocratic gentleman scholar. The work is a compendium of results nearly exclusively not his own, mostly descriptive, and often the author appears as highly credulous and unable or unwilling to see contradictions. Although he does sometimes compare sources according to their own merits, his very busy political life and his overambitious work are more likely to make him fail to satisfy our criteria for science. Unfortunately, he does not at all explain what 'science' is for him or reflect upon what he is doing, and why and how in Latin.

There are quite a few words not previously attested in his work, for example *exacutio* ('whetting'), *incantamentum* ('incantation'), *explicabilis* ('explicable');[98] they are usually formed by suffixation. Depending on the field, his use of Greek words is quite frequent, especially for *realia* such as stones, herbs, and medical conditions. Sometimes he cannot find a Latin name and writes something like *non habet Latinam appellationem* ('it has no Latin name'; *Naturalis historia* XXI.26(50), ed. Ernout et al., vol. 21, p. 44). Only in some fields, such as agriculture, can Pliny make use of an extensive existing Roman vocabulary. He admits himself that his sterile *materia* demands rustic and barbarous vocabulary on occasion, and stresses that he is the first Roman to attempt such a comprehensive work on natural philosophy (I, praef. 12–14, vol. 1, pp. 50–51):

> *Meae quidem temeritati accessit hoc quoque, quod leuioris operae hos tibi dedicaui libellos. Nam nec ingenii sunt capaces, quod alioqui* in *nobis perquam mediocre erat, neque admittunt excessus aut orationes sermonesue aut casus mirabiles uel euentus uarios, iucunda dictu aut legentibus blanda, sterili materia: rerum natura, hoc est uita, narratur, et haec sordidissima sui parte, ut plurimarum rerum aut rusticis uocabulis aut externis, immo barbaris etiam cum honoris praefatione ponendis. Praeterea iter est non trita auctoribus uia nec qua peregrinari animus expetat: nemo apud nos qui idem temptauerit, nemo apud Graecos qui unus omnia ea tractauerit.*
> 'What further adds to my temerity is also that these books I dedicate to you [Emperor Vespasian] contain a rather petty work. Indeed, they allow little ingenuity – which at any rate is extremely mediocre in me – and they do not admit digressions or speeches or dialogues or miraculous examples and sundry adventures, all of which are nice to write and pleasant for readers, due to the sterility of their subject-matter. They expound the nature of things, that is, life itself, including its most abject part, so that for many things, rustic or foreign words – even barbarian ones – have to be employed, albeit with an excuse. Moreover, this approach

97 For an introduction with bibliography, see Fögen (2009: section 5.3).
98 See the list in Healy (1999: 95–99).

> is a path untrodden by authorities, and it is not one that the inquisitive mind seeks out to amble along. There is no one among us Latins who attempted this, no one among the Greeks who alone treated all these things.'

Of course, Pliny's usual style is very different from that in this elaborate proemium. Indeed, as the non-italicised letters show, there is considerable uncertainty in the manuscript tradition in this complicated sentence. As a more typical example, his discussion of comets may be quoted (II.22(89), vol. 2, p. 38):

> *Restant pauca de mundo; namque et in ipso caelo stellae repente nascuntur. Plura earum genera: cometas Graeci uocant, nostri crinitas, horrentes crine sanguineo et comarum modo in vertice hispidas; iidem pogonias quibus inferiore ex parte in speciem barbae longae promittitur iuba.*
> 'A few things remain to be said about the heavens. In fact, also in the sky itself some stars appear suddenly. There are several kinds of them. The Greeks call some "comets"; our authors call them "hairy ones" [*criniti*], as they bristle with blood-coloured hair and are shaggy on top in the likeness of hair. They [the Greeks] call others "bearded ones" [*pogoniae*]; from these a mane is flowing forth from their lower part in the form of a beard.'

His encyclopaedia[99] comprising some 400,000 words is the longest completely preserved Latin work from Antiquity,[100] more than double the size of Isidore's *Etymologiae*. It was to be much copied and used in further digests, and with it his lack of interest in checking sources and his rather unconscious, nonchalant style, making use of whatever linguistic devices happen to be at hand without scruples about elegance of expression. Despite all of this, the work does follow some scientific standards: Pliny believes that authors should cite their sources (praef. 21, vol. 1, p. 53), something he does at the beginning of each book and which makes him quite an exception. He depended heavily on *Hilfswissenschaftler* (slaves) for his huge work. They gathered the material for him, presented it to him, and took down his dictations. This may have reduced the quality of the content. Quintilian (*Institutio oratoria* X.1.128, ed. Rahn, vol. 2, pp. 483–485) tells us that Seneca, who worked similarly, was often cheated by such slaves:

> *Cuius et multae alioqui et magnae virtutes fuerunt, ingenium facile et copiosum, plurimum studii, multa rerum cognitio; in qua tamen aliquando ab his, quibus inquirenda quaedam mandabat, deceptus est.*

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99 Right after this quotation, Pliny tells us that these things *Graeci τῆς ἐγκυκλίου παιδείας vocant* ('the Greeks call of the Circle of Education')

100 The remains of Livy's *Ab urbe condita* are longer (some 530,000 words), but the work has not survived in full.

> 'He [Seneca] had many and great virtues: an easily available and copious talent, great zeal, much factual knowledge, in which, however, he was sometimes deceived by those he sent to get information.'

Pliny died (we might say) in the cause of science when he got too close to the erupting Vesuvius in AD 79. His work was very influential throughout the Middle Ages and into early modern times.[101] Of course, the extremely long work also circulated in (often thematic) abbreviated versions[102] and served as a quarry for later encyclopaedic writers such as Isidore, as did similar huge compendia that have not come down to us in full, for instance those by Varro or Celsus.

§11 The philosophical writer Lucius Apuleius (ca. 125–ca. 180) from Madaura in northern Africa did care about style, but nonetheless he was not afraid to coin new words. His style differs greatly from that of Cicero or other 'classical' writers. It is a great pity that his many works on scientific topics have not come down to us; they treated as diverse subjects as agriculture, trees, astronomy, and medicine.[103] In his *Apologia*, he claims to have worked especially in biology: *ex lectione et aemulatione Aristoteli* ('out of studying and wanting to emulate Aristotle'; 41, ed. Vallette, p. 50). Both his style and his intellectual depth differ so widely among his works that some have been taken to be spurious because they did not seem good enough, in particular his translation of the pseudo-Aristotelian *De mundo*. He also produced other translations from Greek, for example the *De arithmetica* of Nicomachos of Gerasa (the translation is lost). Some of these works may have contained reason to doubt Stahl's disbelieve in the existence of Roman science, despite Beaujeu's scepticism: 'il nous apparaît bien plus comme un compilateur et vulgarisateur, habitué à faire sa pâture de connaissance prises chez les autres, que comme un chercheur et un inventeur' ('he appears to us much more as a compiler and populariser, accustomed to grazing on knowledge taken from others, than as a researcher and inventor'; edition, p. xi).

An example of Apuleius' style may be quoted from *De deo Socratis,* which is basically a well-structured demonological treatise (14, ed. Beaujeu, p. 34):

> *Idcirco supersedebo inpraesentiarum in his rebus orationem occupare, quae si non apud omnis certam fidem, at certe penes cunctos notitiam promiscuam possident. Id potius praestiterit La-*

101 See Maraglino (2012) on some aspects of its impact.

102 Especially on medical topics; two such versions are *Physica Plinii Bambergensis*, ed. Önnerfors, and *Plinii qui feruntur De medicina*, ed. Önnerfors.

103 The very few fragments are collected in Beaujeu's edition. References and further details in von Albrecht (1992–1994: 2:1152).

> *tine dissertare, uarias species daemonum philosophis perhiberi, quo liquidius et plenius de praesagio Socratis deque eius amico numine cognoscatis.*
> 'Therefore, I shall forebear to strain my discourse with these present things, which, although they may not enjoy certain belief by all, are at least of general knowledge. Rather, it would be better to study in Latin the various species of demons recognised among the [Greek] philosophers, by which you may understand more clearly and more fully the presentiments of Socrates and his demon friend.'

Apuleius' style used to be characterised as *tumor africanus* until it was realised that this 'bombast' is not typically African.[104] Other surviving examples of a similar style are Aulus Gellius, Fronto, Tertullian (chap. 9 §2), and Martianus Capella (chap. 9 §5). This post-classical *tumor* can be linked to similar un-Attic approaches in Greek at the same time. Typically for this, Apuleius uses a rich vocabulary: Bernhard (1927: 141) counted 233 words that are not recorded before him in the *Metamorphoses* alone. Most of them are formed by adding prefixes and/or suffixes – which will remain the usual way to extend Latin vocabulary, especially in scholastic times when stylistic reluctance is fully overcome – but there are also some true compounds, such as *multiscius* ('knowing much'). Wellstein (1999: 41) found that the suffixes *-tio, -tus, -tas, -bilis, -bundus,* and *-osus* are especially frequent. Enriching the vocabulary does seem the way of choice in order to treat unfamiliar scientific topics, although stylistic bombast would tend not to seem very useful for scientific communication. As Apuleius used very different types of language in his various works, it is hard to say what kind of Latin he used in his lost scientific treatises.

It would be interesting to study the language of the second-century scientific literature in Latin besides Apuleius that is bound to have existed – in this time of the greatest extent of the Roman Empire and relative peace and prosperity. Unfortunately, not much is left, and close to no non-Christian Latin literature survives from the more turbulent third century either. At least some other learned authors are known: Censorinus (fl. 238), from whom a birthday present, *De die natali*, is preserved and a grammatical work, *De accentibus,* is known, or the agricultural writer Gargilius Martialis (d. 260), of whom some fragments survive. Another erudite author in these times was Sammonicus Serenus (d. 212), who is said to have possessed a library of 62,000 volumes; few fragments of his writings remain.[105] The neo-Platonist antiquarian writer Cornelius Labeo may also have lived in the

104 First by Norden (1958: 2:596–597).

105 On these two authors, see Bardon (1952–1956: 2:260–263). The latter is not identical with the author of a didactic poem *De medicina* by another Quintus Sammonicus. Bardon also mentions (266) some more authors, mostly grammarians, who are known to have been active.

third century, the very few fragments are edited by Mastandrea. But these times were at least the heyday of classical Roman law.[106]

Classical Roman law

§12 The second and early third centuries AD, especially under Trajan and Hadrian, are the acme of the development of Roman law as it was to have lasting influence on the development of legal systems worldwide. Later times canonised five great jurists: Gaius (fl. 161), Iulius Paulus Prudentissimus (fl. ca. 210), Aemilius Papinianus (142–212), Gnaeus Domitius Annius Ulpianus (ca. 170–223), and Herennius Modestinus (fl. 240).[107] In addition to these jurists, some others were at least as influential in their time, especially Salvius Iulianus (ca. 110–ca. 170). There were several legal schools, of which we know but little; in particular, the sources differentiate the *Sabiniani* (or *Cassiani*) and the *Proculiani*. There do not seem to have been great methodological differences, though. Masurius Sabinus' (first century AD) lost *Libri tres iuris civilis,* apparently containing short, aphoristic rules, was much commented by adherents of the *Sabiani*.[108] The work's form prompted its use as a point of departure for the elaboration of the commentator's own thoughts – a very similar thing will happen with Peter the Lombard's *Liber sententiarum* in theology in the twelfth century.

A list of important juridical works survives in the so-called *Index florentinus;*[109] it lists the works from which Justinian's experts excerpted for the *Digesta*. Of these, unfortunately, only Gaius' introductory work *Institutiones* survives in full, and this only by its fortunate conservation on a palimpsest (see fig. 12). It may be called a legal primer, written around AD 161. Although Gaius does not use the terms *scientia, disciplina,* or *ars,* even the opening of his work makes its pretensions as a scientific handbook clear (*Institutiones* 1.1, ed. Manthe, p. 36):

> *Omnes populi, qui legibus et moribus reguntur, partim suo proprio, partim communi omnium hominum iure utuntur; nam quod quisque populus ipse sibi ius constituit, id ipsius proprium est*

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106 'Le IIIe siècle ne paraît pas beaucoup mieux fourni en prosateurs qu'en poètes. Seuls, émergent d'éminents juristes' ('The third century does not seem to be much better supplied in prose writers than in poets. Only some eminent jurists appear'; Bardon 1952–1956: 2:259). Leonhardt's (2013: 80) statement may be somewhat too strong: 'As far as prose is concerned, only one genre was really alive between the second and the early third century: jurisprudence.'

107 Vol. 15 of *ANRW* dedicates a chapter each to our knowledge of these authors; for an overview of their background in society, see Kunkel (1967).

108 See Liebs (1976).

109 Schulz (1961: 170–173). Edition: *Digesta Iustiniani Augusti*, ed. Krüger & Mommsen, vol. 1, pp. lii–lvi.

vocaturque ‘ius civile’, quasi ius proprium civitatis; quod vero naturalis ratio inter omnes homines constituit, id apud omnes populos peraeque custoditur vocaturque ‘ius gentium’, quasi quo iure omnes gentes utuntur. Populus itaque Romanus partim suo proprio, partim communi omnium hominum iure utitur; quae singula qualia sint, suis locis proponemus.
‘All people governed by laws and customs use partly their own law and partly that of all mankind. For whatever any people constituted as its law is its own and is called *ius civile*, as if the law of its own civilisation; but whatever natural reason constituted among all peoples, and what is kept by all people in the same way, is called *ius gentium*, as the law which all people use. Thus, the Roman people use partly their own law, partly law common to all people. Which is which will be told in its proper place.’

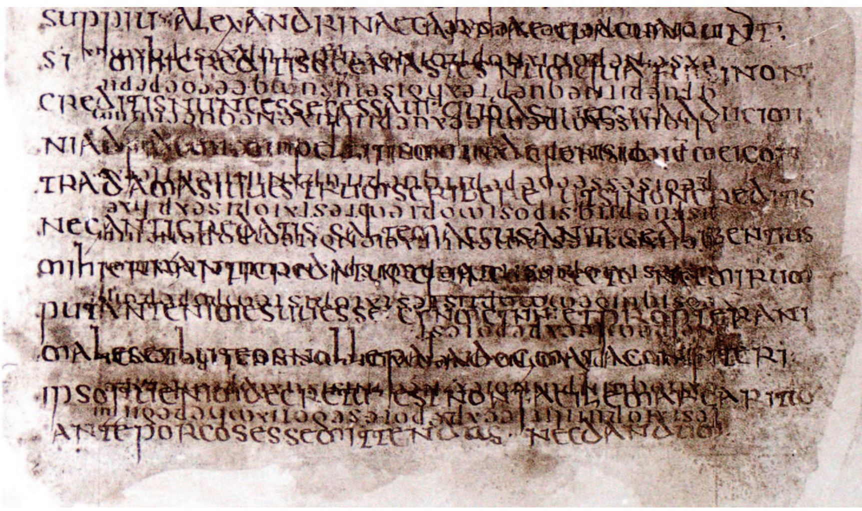

Fig. 12: Gaius, *Institutiones* survives only in a palimpsest (Verona, Biblioteca capitolare XV (13), fifth century, here: II.211–214). The upper (larger) writing is by Jerome.
Source: Spagnolo (1909: 5).

The language used by Gaius is very clear, logical, and linear, although the text is a kind of hypomnemata for teaching and was not polished by the author.[110] Manthe (edition, p. 13) concludes that his language is somewhat colloquial: there are some *anacolutha*, occasionally an *ut* with the infinitive, and such like. Söllner describes it as ‘sich durch Knappheit und den Verzicht auf ungebräuchliche und gefühlsbeladene Wörter auszeichnet’ (‘characterised by brevity and the renunciation of unusual and emotionally charged words’; 1996: 106).

110 See Schulz (1961: 193–197).

Modestinus, the last of the five great jurists, wrote both in Latin and in Greek. There is an interesting testimony from him about the difficulties of expressing Roman legal thought in Greek (in contrast to the frequent complaints the other way round). Modestinus wrote at the very beginning of his *Liber excusationum* (preserved in Justinian's *Digesta* D 27.1.1, ed. Krüger & Mommsen):

> Ἑρέννιος Μοδεστῖνος Ἐγνατίῳ Δέξτρῳ. συγγράψας σύγγραμμα, ὡς ἐμοὶ δοκεῖ, χρησιμώτατον, ὅπερ παραίτησιν ἐπιτροπῆς καὶ κουρατορίας ὠνόμασα, τοῦτό σοι πέπομφα. Ποιήσομαι δὲ ὡς ἂν οἷός τε ὦ τὴν περὶ τούτων διδασκαλίαν σαφῆ, ἀφηγούμενος τὰ νόμιμα τῇ τῶν Ἑλλήνων φωνῇ, εἰ καὶ οἶδα δύσφραστα εἶναι αὐτὰ νομιζόμενα πρὸς τὰς τοιαύτας μεταβολάς.
> 'Erennius Modestinus to Egnatius Dexter. I wrote a book that, as it seems to me, is very useful, which I named *Refusal* [*excusatio*] *of Stewardship and Curatorship*, and now send it to you. I shall make the teaching about these matters as clear as I am able to, explaining the legal matters in the Greek language, although I know that they are held to be hard to express in such an alteration [of language].'

Modestinus sometimes just transliterates technical vocabulary: κουράτωρ < *curator*, ὀρατίων < *oratio* (in the sense of 'legislative proposal of the emperor'), λεγεωνάριος < *legionarius,* πριμιπιλάριος < *primipilarius,* ἰνκόλα[111] < *incola*. But there are also cases where, apparently, an accepted Greek equivalent did exist, such as ἐπίτροπος = *procurator*. Occasionally, there are also new Greek coinings containing Latin parts, such as κουρατορεύω ('serve as a *curator*'), συνβετερανός < *conveteranus*.[112] This shows that there were also difficulties in translating Roman scientific texts into Greek in cases where the Roman form of the science was more advanced. Unfortunately, few such cases have survived – even Modestinus' Greek is preserved only in fragments – but it would still appear that Greek had less trouble expressing Latin thought than vice versa (on which see chap. 10 §5 below).

Kaser (1965) studied the amount of technicality in classical legal Latin and found that some features of later technical legal Latin are not yet fully apparent: most clearly, abstract nouns seem to be avoided, the action being expressed verbally instead (138). Later on, deverbal nouns in *-tio* will become more frequent (*adsignatio, occupatio*, *usurpatio*, etc.). Thus, the use of nouns instead of verbs (*gestio*, not *gerere*) seems to have been preferred for fixing concepts, in a manner similar to what scholastic Latin was to do in philosophy and theology in the thirteenth century. In juridical terminology, technical terms may be abstracted from the common language, but they may also return to common language (99).

111 With unexpected accentuation.
112 All these words are preserved in the *Digesta*. Passages can easily be found in Corpus Corporum.

The technical terminology can be characterised by unambiguity, economy, perspicuity – the very characteristics expected in scientific language (chap. 7 §6). Rhetorical ornamentation, overly emotional terminology, and metaphors were shunned.[113] The language of law, still today very much based on the Roman one, may be said to represent a typically Roman *Denkstil* of learning that differs conspicuously in some respects from the Greek scientific one.

When the Principate was changed into a more absolute monarchy (the Dominate) by Diocletian (AD 284), legal questions lost much of their interest as the emperor gained more power, including legal power. Later times mostly just compiled and epitomised earlier sources. How they do this can occasionally be glimpsed if both texts survive. Gaius, *Institutiones* I.49, ed. Manthe, p. 54, reads:[114]

> *Rursus earum personarum, quae alieno iuri subiectae sunt, aliae in potestate, aliae in manu, aliae in mancipio sunt.*
> ‘Again of these people who are subject to another's law, some are under someone's power [i.e. of the *pater familias*, such as house children and slaves], some are under legal control [i.e. wives married *cum manu*], some are so by formal acceptance [i.e. gaining transitory power over e.g. other freemen's children].’

The fifth-century *Epitome Gai* 1.3, pr., ed. Baviera, p. 235, simplifies radically to:

> Aliquae personae sui iuris sunt, aliquae alieno iuri subiectae sunt.
> ‘Some people are *sui iuris*, some are subject to someone else.’

Clearly, the various legal categories had become obsolete. The five jurists became the sole authority in later times: Theodosius II (401–450) prescribed that only they could be cited in legal cases; in the case of disagreement, the majority was to prevail, or Papinianus' view if there was a tie.[115]

Among the types of literature the Roman jurists wrote, the following can be distinguished: (i) overviews and school material (surviving: Gaius, *Institutiones*; and, in post-classical *réécriture*, *Pauli sententiae,*[116] *Ulpiani Regulae, Fragmenta Vaticana*); (ii) commentaries, already on the Twelve Tables (e.g. by Antistius Labeo, ca. 54 BC–ca. 10 AD) and later on works such as that of Sabinus, and probably most commonly the text of the Praetor's Edict (*edictum praetoris*), which was extended every year; and (iii) casuistic texts in a broad sense: *libri responsionum,*

113 Carcaterra (1968: 17); Schulz (1961: 331–334).
114 Example from Söllner (1996: 130).
115 Söllner (1996: 127).
116 See Schulz (1961: 213–217).

digesta, *quaestiones*, and so on.[117] Of course, these types may approach one another in some texts; commentaries, in particular, often contained casuistics too. In general, and quite contrary to the expectations we have from other sciences, introductory texts (i) used a more abstract approach; the more advanced a text, the less rule-based it seems to become.[118] According to the distinctions drawn above (chap. 5 §1), (iii) would make up the most scientific part, where legal science was further developed. Unfortunately, these texts are all lost. The legal material the Romans produced in the times of classical Roman law must have been enormous, so extensive that in Late Antiquity Theodosius II and then Justinian decided to have it collected and abbreviated in order to put it to use again. What survives today comes from these collections; Justinian's has been known as the *Corpus iuris civilis* since the twelfth century.[119] Much of the corpus goes back to the five great jurists. Justinian told his specialists, led by Tribonian (d. 542) (C 1.17.2.10, ed. Krüger & Mommsen):

> *Tanta autem a nobis antiquitati habita est reverentia, ut nomina prudentium taciturnitati tradere nullo patiamur modo, sed unusquisque eorum, qui auctor legis fuit, nostris Digestis inscriptus est; hoc tantummodo a nobis effecto, ut, si quid in legibus eorum vel supervacuum, vel imperfectum, vel minus idoneum visum esset, vel adiectionem vel deminutionem necessariam accipiat et rectissimis tradatur regulis.*
> 'We have such reverence for the ancient jurists that we will by no means allow the names of the sages to be passed over in silence, but each of those who was the author of a law will be named in our *Digesta*. We only elaborate them so that if something in them seems to be superfluous or imperfect or less apt, the text will receive a necessary addition or cancellation and will be passed on in the form of the most correct rules.'

It is disputed among specialists how much alteration the texts suffered in the course of incorporation into the Justinian collection. On the whole, the changes will mostly have involved the shortening of passages no longer relevant, usually not as strongly as in the above example.[120] As Latin was hardly used in Justinian's Eastern Empire, he allowed the texts to be translated into and also to be used in Greek.[121]

117 Söllner (1996: 110–113). Schulz (1961: part 3, chap. 4) differentiates more finely between *Formelsammlungen*, *isagogische Literatur*, *Regulae/Definitiones/Differentiae/Sententiae/Opiniones*, *Kommentare*, *Problemata*, *Instruktionsschriften für Magistrate*, and *Monographien*. For more on the narrative approach in various legal genres, see Babusiaux (2016).
118 In classical times, '[a]bstrakte, prinzipielle Formulierungen findet man hauptsächlich in elementaren Schriften' ('abstract, principle-based formulations are mainly found in elementary writings'; Schulz 1961: 153).
119 Schanz & Hosius (1922–1935: 4.1:187–189). Edition by Krüger & Mommsen. Its constituents are arranged by author in Lenel, *Palingenesia*.
120 As Söllner (1996: 146) concludes.
121 Söllner (1996: 134).

The Justinian law was to re-emerge at the school of Bologna under Irnerius (twelfth century; see chap. 10 §1) in the West; in Byzantium it remained in force at least to some extent as long as the Empire lasted. Emperor Leo VI had a summary made around the year 892, called the Βασιλικά.

Relations to criteria for science

§13 It is time to sum up and review the authors and texts from this epoch and to consider whether their activities can be called scientific according to the criteria proposed above (chap. 4 §5). Varro in his *De lingua latina* strove to understand the Latin language using a systematic method (criterion I) in a coherent way (IV), and he certainly based himself on a Hellenistic community effort (V). He is somewhat lacking when it comes to presenting mechanisms (II) and testability (III), but both these criteria only became important in linguistics from the nineteenth century onward, when historical linguistics discovered the sound law; testability is still only occasionally found in linguistics today. How much of Varro's erudition was his own addition to the Hellenistic literature he had devoured, is a matter of speculation, as practically nothing of either survives. Lucretius' aims were not scientific; rather, he can be seen as an Epicurean missionary (and an excellent poet), not a scientist.[122] Cicero was not too deeply interested in theoretical details of Greek learning – indeed, he admits to having failed in them – and more concerned with rhetoric and the shaping of the Latin language. In contrast to Varro, he did not write any encyclopaedic works. His attitude toward Greek natural science is negatively characterised by Stahl (1962: 79):

> Cicero's line of argument draws uncomfortably close to the attitude of a facile lawyer who in handling accident cases has acquired from medical reference books so many bits of anatomical, physiological, and neurological information and has so often succeeded in confuting the professional testimony of doctors in court that he sincerely believes he 'knows more medicine than the doctors'.

But his interest in politics may well be said to have been of a scientific nature, as has been argued for *De re publica*. His importance in the present context was certainly greater as an innovator in the Latin language than as a scientist proper.

In Fleck's terminology (chap. 5 §1 above), Seneca's *Quaestiones naturales* could be termed *Handbuchwissenschaft*, as it collects results from many Greek studies and argues for or against them. In some cases, he does seem to improve

122 Stahl (1962: 83) rightly puts this as: 'his significance should be judged as a poet, not as a scientist.'

existing theories, especially in cometology. In other fields, such as lightning, which was quoted as an example, there was no way to get a better understanding without much of the knowledge of modern physics and chemistry. His approach was certainly systematic (I) and often explained step-by-step, even offered mechanisms (II); it was coherent (IV) and based on the Hellenistic community effort (V). The difference from today's science may be that the latter is much more testable (III) and its theory formalised (VI). Quite in general, the main difference between Seneca and the argumentation of the early 'pre-Socratics', some of whom wrote similar works, is that more details were available in his time, the logic is sounder, and the theories became more realistic. Thus, Seneca's work may count as quite scientific, even if not very independent.

Quintilian wrote a well-structured and methodological, 'scientific', introduction to rhetoric in Latin for the first time (as far as we know). He is very systematic (I) and coherent (IV). But rhetoric is a practical art, not a science proper: its aim is to produce good orators, not to explain things step-by-step (II). Quintilian was to become much read among Renaissance humanists. Although Pliny certainly had a scientific inquisitiveness, his encyclopaedic work can at best be seen as a handbook, and moreover one with little critical awareness. Matters may have been different with Apuleius, but unfortunately, those of his works that may have been most scientific in nature are lost. His atypically open approach to coining new words was to become important. In general, we may wonder how much more scientific material has been lost to us: two important works discussed here are only extant on a single palimpsest each.

Up to now, everything mentioned clearly involves the taking over of a Greek scientific *Denkstil*, which sometimes worked well, sometimes less so. However, the best candidate for a genuine Roman science in this epoch is classical jurisprudence, although again its central importance for the Romans was that of an art, and therefore its applicability, not its theoretical system, stood in the centre. Thus, the explanatory and theoretical criterion (II) is not met. But this body of knowledge was certainly systematic (I), impartial (III), coherent (IV), and the fruit of a community effort (V), and its language was formalised (VI). Its language and its text genres are reminiscent of much later scholasticism at the thirteenth-century universities: unambiguity, economy, perspicuity were sought; rhetorical ornament, overly emotional terminology, and metaphors were shunned. New nouns were formed using suffixes. Important genres include *quaestiones* and commentaries on systematic works. As the preservation of legal sources from the Principate is so bad, it is difficult to get a precise picture of any more theoretical approaches that might well have existed.

9 The age of the *artes liberales*

§1 For the history of Latin science there are good reasons to consider later Antiquity and the Early Middle Ages[1] before the introduction of Greek science in the twelfth century as one single period. Within this time span, scientific and scholarly writers shared important characteristics, most conspicuously the scheme of the *artes liberales* for addressing advanced learning. Other points include the fact that they were mostly Christians, which entailed some changed attitudes toward language, learning, and society in general compared to their pagan predecessors. For example, the Christian attitude toward manual work was much less elitist than that of Graeco-Roman pagan intellectuals; consequently, the separation between theoretical and practical science is less clear-cut.[2] In terms of science, this epoch has been called 'l'ère des manuels et des résumés' ('the era of manuals and résumés'; Hadot 1955: 235). This is especially true for sciences of little or no practical use, such as the mathematical and natural sciences.[3] The scientific background is more Platonist than Aristotelian. Knowledge of Greek became rarer in later Antiquity, even among the most educated Romans – a typical example is Augustine, who read Greek badly at best – thus, the influx of Greek innovation also dried up. The Liberal Arts (*artes liberales*) are the usual umbrella term for the sciences widely taught at schools through this epoch.[4] They are called 'liberal' because they are fit for free men (ἐλεύθεραι or ἐλευθέριοι τέχναι), as Seneca had already held (*Epistola* 88.2, ed. Stückelberger, p. 84):

> *quare liberalia studia dicta sint, vides: quia homine libero digna sunt. ceterum unum studium vere liberale est: quod liberum facit, hoc est sapientiae, sublime, forte, magnanimum. cetera pusilla et puerilia sunt.*
> 'You see why they are called "Liberal Arts": because they are worthy of a free man. Otherwise, there is only one study that is really "liberal", viz. that makes free, and that is the study of wisdom; it is exalted, strong, magnanimous, all the others are trifles and childish.'

These arts can be traced back to the ἐγκύκλιος παιδεία in Antiquity and a feeling that all sciences form a single whole.[5] The concept thus goes back to the preced-

1 For a century-by-century characterisation of the literature and thought of sixth to the fifteenth century, see Leonardi (2002).
2 As Hägermann & Schneider (1991: 323) rightly point out.
3 A detailed list of scientific writers from Late Antiquity can be found in Hadot (1984: 253–260). For knowledge of Greek, see Courcelle (1948).
4 For details see D'Alverny (1946). See also Riché (1962), and esp. Hadot (1984). For an introduction to the *artes liberales*, see Christes (1996).
5 On which see Hadot (1984: chap. 6).

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ing epoch, but it is only in Augustine's *De ordine* that their sevenfold canon can be observed with certainty for the first time,[6] yet even in later works by Augustine, this sevenfold classification is not upheld: in *De doctrina christiana*, several sciences studying perishable nature are named together with the seven.[7] In earlier authors, we find deviant lists of 'free' *artes*. Varro, for instance, did treat at least some of the seven in his lost *De disciplinis*, but he also includes *medicina* and *architectura* (see chap. 8 §5 above).[8] Typically for Platonism, the Liberal Arts do not comprise studies of perishable things (as physics, medicine, or biology do); thus, they fit in well with the Platonic turn in mediaeval Latin philosophy before the twelfth century: the Seven Arts are propaedeutic not so much for philosophy in general as for Platonic philosophy (Hadot 1984: 132). Among these seven disciplines, three deal with language and man's use of it (out of which the human sciences would develop), and were known as the *trivium* in the Middle Ages.

- *Grammatica* studied words, parts of speech, and kinds of phrases and sentences. It can also be seen as an ancestor of our linguistics, and it can even include the scientific study of history (*historia*).[9]
- *Dialectica* was the art of argumentation, kinds of statements, syllogisms, and so on, which developed into logic. In the Middle Ages, *dialectica* was mostly studied using Boethius' translations of Aristotle's *Organon* (lacking the *Analytica posteriora*).

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6 Hadot (1984: chap. 4).

7 He is arguing that *animalium, herbarum, etc., praesertimque siderum cognitio* as well as the *mechanicae artes* are useful to understanding of Scripture (cf. chapter headings 29 and 30 in the PL edition). This point is made by Hadot (1984: 136).

8 Hadot (1984: chaps 3–4) develops the details of the formation of this canon. Greek authors also have differing lists, e.g. Galen: εἰσὶ δ' ἐκ τοῦ προτέρου γένους ἰατρική τε καὶ ῥητορικὴ καὶ μουσική, γεωμετρία τε καὶ ἀριθμητικὴ καὶ λογιστική, καὶ ἀστρονομία καὶ γραμματικὴ καὶ νομική ('There are among the former [i.e. the non-physical, "liberal"] arts: medicine, rhetoric, music, geometry, arithmetic, practical arithmetic, astronomy, grammar, and law'; *Adhortatio ad artes addiscendas* 14, ed. Kühn, vol. 1, p. 39) – thus adding medicine and law to the usual seven.

9 Augustine states: *Poterat iam perfecta esse grammatica sed, quia ipso nomine profiteri se litteras clamat – unde etiam Latine litteratura dicitur – factum est, ut, quidquid dignum memoria litteris mandaretur, ad eam necessario pertineret. itaque unum quidem nomen, sed res infinita multiplex curarum plenior quam iucunditatis aut ueritatis huic disciplinae accessit, historia non tam ipsis historicis quam grammaticis laboriosa* ('Grammar could now be complete, but as by this name "letters" are addressed – whence Latin *litteratura* – it happens that everything worth remembering and that is written down necessarily also belongs to grammar. Thus, a single name was given to this discipline, but the matter is an infinite multitude fuller of worries than delight or truth, history being laborious not only to historians but also to grammarians'; *De ordine* II.12(37), ed. Doignon, p. 274). Similarly already Quintilian (*Institutio oratoria* I.8.18, ed. Rahn, vol. 2, p. 122).

- *Rhetorica* was originally intended to train students for speeches, especially at court. As such, it is akin to jurisprudence (focusing on oratory). In studying figures of thought and of speech, it is also related to modern literary studies.

For all of them, the main method in the Middle Ages was the study of classical Latin texts. Apart from these linguistic arts, the *artes liberales* comprise the four mathematical sciences. Boethius originally coined the term *quadruvium* for them, from the Greek τέσσαρες μέθοδοι used by Nicomachos of Gerasa (*Introductio arithmetica* I.4, ed. Hoche, p. 9), who explained their topics as:
- *arithmetica*, studying discrete, unmoved quantity;
- *geometria,* continuous, unmoved quantity;
- *musica* (i.e. harmonics), discrete, moving quantity (tones);
- *astronomia* (usually including astrology), continuous, moving quantity (the heavenly bodies).[10]

Thus, they all study quantity and were strongly based on mathematics. These four sciences had already been mentioned and stressed as important for teaching by Plato (*Respublica* VII, 520–540). The first two would now be subsumed under mathematics, the last two under mathematical physics. The sevenfold number of these arts, in a Christian environment, nicely fits the biblical passage (Prov. 9:1):

> *Sapientia aedificavit sibi domum, excidit columnas septem.*
> 'Wisdom built for itself a house, it hewed out seven columns.'

The Seven Arts became the usual classification of the disciplines in the Early Middle Ages through the influential works of Augustine, Martianus, and Cassiodorus, and were taught in school at least from Carolingian times onward, although the mathematical sciences were not – with a few exceptions (especially in *computus*) – cultivated much beyond basic school learning.[11] Their naming as *artes* is somewhat surprising, as they lack the practical aim of producing an *opus;* but as pointed out above (chap. 3 §4), the term *ars* can be synonymous with *disciplina* and *scientia*. It has also been stressed (chap. 1 §1) that Cassiodorus called some of these branches of learning *artes* and others *disciplinae*. In his *Institutiones*, rhetoric and grammar are among the former, and the mathematical

10 This scheme of dividing the quadruvial arts using movement and continuity was common. For example, it is also used by Proclus, *In Euclidem* prol. 1, ed. Friedlein, pp. 35–36.
11 On the study of these mathematical fields in the Middle Ages, see Englisch (1994); Klinkenber (1959). On a different classification of philosophy/science in the Early Middle Ages, see Bischoff (1958).

sciences among the latter. He is uncertain which kind *dialectica* (including logic) should belong to (praef. 4, ed. Mynors, p. 92). Thus, he comes close to our understanding of 'science', which would not include elementary grammar and rhetoric, either.

Fig. 13: Universitätsbibliothek Leipzig, Ms 1253, fol. 3r, a Boethius manuscript depicting Lady Philosophy with a ladder made up of the Liberal Arts. Reproduced with permission.

The Liberal Arts are also known as *ingenuae disciplinae*, by Cicero, for example,[12] as yet without a clear canon, but even Cassiodorus and Isidore no longer understand the name: they take the word *liberalis* to refer to books (*libri*).[13] This illus-

12 *De finibus* II.67, ed. Moreschini, p. 65.

13 *Institutiones* II, praef. 4, ed. Mynors, p. 91; *Etymologiae* I.4.2, ed. Lindsay.

trates a shifting emphasis between the pagan and the Christian *Denkstil*, replacing aristocratic liberty with book learning. The canon remains largely unquestioned in the Middle Ages up to the translation movement in the twelfth century.[14] These Seven Arts are often depicted symbolically in manuscripts, as in figure 13. Such a canon of Seven Liberal Arts was unknown in Byzantium, where education seems to have remained closer to Hellenistic ways, including grammar, rhetoric, philosophy (including the *Organon*), physics, the *quadrivium*, theology.[15] Some mediaeval Latin authors try to construct seven corresponding mechanical or practical arts to counterbalance the seven theoretical ones. The name *artes mechanicae* occurs first in Firmicus Maternus,[16] and Eriugena in his commentary on Martianus Capella suggests that there should also be seven of them. Hugh of St Victor finally proposes a list, albeit one that makes a rather ad hoc impression:[17] *lanificium, armaturam, navigationem, agriculturam, venationem, medicinam, theatricam.*

Late Antiquity is often said to begin with Diocletian's reforms after AD 284 and the introduction of the Dominate, or alternatively with Constantine's adoption of Christianity (312).[18] Many things change in the fourth century. Scholars and intellectuals in Late Antiquity were sometimes still active at the imperial court (as late as Boethius), while others will still have been private gentleman scholars (possibly Martianus Capella). But from the time of Cassiodorus onward, they tend to be monks and work in monasteries stocked with libraries.[19] In addition to these, in the Early Middle Ages cathedral schools storing the knowledge of the past became important: both organisations were run by the Church and were most strongly interested in propaedeutic teaching manuals and theology – in keeping with Augustine's *De doctrina christiana* (see §2 below). In what follows, the typical ingredients of the *Denkstil* of the Liberal Arts in this epoch are considered: Christian scholarship (§2), Christian neo-Platonism (§3), the study and use of Latin (§4), the use of compendia on science and some important authors (§§5–7,

14 With very few exceptions, such as Eriugena, who doubts the canonical ordering and would, again, exclude the 'man-made' arts of rhetoric and grammar (*Periphyseon* PL 869D–870B, V.4, ed. Jeauneau, vol. 5, pp. 15–16).

15 See Praechter (1910), Browning (1963), and now Pérez Martín & Manolova (2020).

16 *Mathesis* VI.30.26, ed. Monat, vol. 3, p. 83.

17 *Didascalicon* 3.1, ed. Offergeld, p. 216. On the *artes mechanicae* in the twelfth century, see Alessio (1984).

18 The first date is current among historians, as Diocletian restored order and stability in the Empire. The latter date marks the starting point of, for example, vol. 4 of Schanz & Hosius (1922–1935).

19 For an introduction to mediaeval monasticism, see Lawrence (1992).

11), and some historical developments concerning our subject during the main periods of the Early Middle Ages (§§8–10, 12).

Scientific approaches among the Church Fathers

§2 No Christian authors have been treated as yet, so we must move back in time, as Christianity developed intellectually in the Graeco-Roman milieu discussed in the previous chapter. At least from the late second century onward, Christianity began to absorb the philosophical backgrounds of its surroundings, which were first Stoic, then (and foremost) neo-Platonist.[20] Like the former, Christian authors emphasised the practical importance of improving one's soul; like the latter, they held theology to be the most important 'science', its goal being to determine scientifically the nature of the Godhead and its rapport with world and soul. The lower reaches of the world inhabited by us ('nature') were clearly of secondary importance; the most important sciences besides theology were the mathematical, non-material ones – a state of affairs that Christians took over and that was to last until the twelfth century. The methods the early Christian theologians employed were (biblical) scholarship and discussions between leading spiritual authorities, apparently based on experience in their own spiritual lives and those of their flocks. Many of the deepest thoughts in this field were expressed in Greek (especially by the Alexandrian and Cappadocian Fathers), but here the Latin literature is also considerable.

The Roman ideals of language and rhetoric and of philosophical and scientific plausibility came to be largely shared by intellectual Christians, and they proved useful for missionary activities among intellectual pagans. It may be objected that these Christian authors were not 'disinterested' and thus disqualified as scientists, but the same can be said about practically all Roman authors studied in the previous chapter. Some were more interested in the art of speaking; others were also missionaries, albeit for their own philosophico-religious systems: the Epicurean Lucretius or the Stoic Seneca resemble the Christian Augustine in this respect rather closely. Soon some of the Christians also wrote scholarly or philosophical treatises that had little or nothing to do with religion. In their own Scriptures, Christians could learn the importance of *scientia* from Isaiah 11:2–3:

> καὶ ἀναπαύσεται ἐπ' αὐτὸν πνεῦμα τοῦ θεοῦ, πνεῦμα σοφίας καὶ συνέσεως, πνεῦμα βουλῆς καὶ ἰσχύος, πνεῦμα γνώσεως καὶ εὐσεβείας· ἐμπλήσει αὐτὸν πνεῦμα φόβου θεοῦ.

20 See Inglebert (2001). The Christian relation to pagan παιδεία is studied by Gemeinhardt (2007).

> *Et requiescet super eum spiritus Domini: spiritus sapientiae et intellectus, spiritus consilii et fortitudinis, spiritus scientiae et pietatis, et replebit eum spiritus timoris Domini.*
> 'And the Spirit of the Lord shall rest upon him: the Spirit of wisdom, understanding, counsel, fortitude, science and piety, and the spirit of fear of the Lord shall fill him.'

So, *scientia* was one of these Seven Gifts of the Holy Spirit in the Latin form of the Bible, although in Greek, which uses γνῶσις, more general knowledge/wisdom seems to be intended (in keeping with the original Hebrew *daʿat*).[21] This passage became important to Latin Christian theologians and was often commented.[22] It will be seen in chapter 11 how Aquinas argues that theology – at least in its scholastic form – is a *scientia*. Other biblical passages also seemed to encourage natural science.[23] Thus, we can speak of a Latin Christian *Denkstil* which had imported a lot from Greek *Denkstile*, although only to some degree its most scientific (Aristotelian) constituents. This combination proved lasting and stable, although not very conducive for innovative science. The four most important early Latin writers in our context are now briefly introduced.

Quintus Septimius Florens Tertullianus (ca. 160–ca. 225) may not count as a scientist in even the broadest sense, even if we concede that Christian theology can be a *scientia*, but his language is of great importance in the present context.[24] Although Tertullian was the first Christian writer who wrote 'serious' theology in Latin (not in Greek), he was more of an ecstatic and mystic than a scholar. He does not hide his disdain for philosophy and learning outside Christianity; he is famous for his rhetorical question *Quid ergo Athenis et Hierosolymis?* ('What does Athens have to do with Jerusalem?'; *De praescriptionibus haereticorum* 7, ed. Refoulé, p. 193).[25] In order to express his extravagant new ideas, he often introduced daring novelties into his language, which has aptly been termed a *Flammensprache* (Norden 1958: 2:606). Among his many new words, the most success-

21 A similar case is found in Hosea 4:6: *Conticuit populus meus, eo quod non habuerit scientiam: quia tu scientiam repulisti, repellam te [...]* ('My people have become silent as they lacked knowledge [*scientia*], because thou hast rejected knowledge, I shall reject thee [...]'). Again Greek uses γνῶσις, Hebrew *daʿat*.

22 Hugh of St Victor, for instance, was to write an entire treatise on these Seven Gifts (*De septem donis spiritus sancti*, ed. Siri).

23 Famously, Wisdom 11:21: *sed omnia in mensura, et numero et pondere disposuisti* ('but Thou hast disposed everything by measure, number, and weight').

24 e.g. '[...] welche entscheidende Stelle Tertullian in der Geschichte des christlichen Lateins einnimmt' ('[...] what a decisive position Tertullian occupies in the history of Christian Latin'; Demmel 1944: 129).

25 Instead, he advocates (in the next sentence) *simplicitas cordis*.

ful was certainly *trinitas* ('Trinity') to translate τριάς; other useful words first attested in him are, for instance, *scibilis* (loan for ἐπιστητός), *multinubentia* (πολυγαμία), *discentia* (μάθησις), *reminiscentia* (ἀνάμνησις), *concupiscentivum* (for Plato's ἐπιθυμητικόν).[26] Some of his linguistic experiments failed to find imitators, such as *baptizator* instead of *baptista*. Some others, such as *scibilis,* become frequent only much later (in this case in Aquinas or Lullus). His language is idiosyncratic; he uses some Latin words with meanings known only from him, for instance *expungo* as 'fulfil' and 'record'.[27] But his language is also full of Greek syntactic influences, for instance in the use of participles and infinitives.[28] Tertullian's often daring style, full of neologisms and similar to that of Apuleius, has to be seen in conjunction with the Second Sophistic. Von Albrecht points out: 'Damals entsteht die lateinische Sprache der Theologie; sie wird zur Mutter der neueren Philosophie' ('It was then that the Latin language of theology was born; it was to become the mother of modern philosophy'; 1992–1994: 2:1222). A passage from *De anima* (57, ed. Waszink, p. 76) will illustrate his language:

> *Quid ergo dicemus magian? quod omnes paene, fallaciam. Sed ratio fallaciae solos non fugit Christianos, qui spiritalia nequitiae, non quidem socia conscientia, sed inimica scientia novimus, nec invitatoria operatione, sed expugnatoria dominatione tractamus multiformem luem mentis humanae, totius erroris artificem, salutis pariter animaeque vastatorem; sic etiam magiae secundae scilicet idololatriae, in qua se daemones perinde mortuos fingunt, quemadmodum in illa deos.*
> 'What will we, then, call magic? Like most men: an imposture. But it is a kind of imposture that only we Christians do not fail to recognise. We alone have uncovered these spirits of evil, not indeed by having been their accomplices, but by a science hostile to them. Not by any procedure attracting them, but by overpowering dominion, we treat that manifold plague of the human mind, that artificer of all error, devastator of both salvation and soul; also that of the second kind of magic, of idolatry, in which demons pretend to be defunct people, similarly as in the other gods.'

His special language has been studied in detail.[29] Braun (1977: 547–548) provides a list of terms that are quite certainly his invention:

26 Other examples in Springhetti, *Latinitas fontium*, p. 28. His predilection for *-entia*/*-antia* was studied by Demmel (1944), who finds thirty-six such neologisms (129).
27 See the entries in Lewis & Short and Georges. Further examples are provided by Norden (1958: 2:607). Teeuwen (1926) studied these cases.
28 Examples in Norden (1958: 2:608–609).
29 On his innovative language, see e.g. Löfstedt (1920); Braun (1977); Fredouille (1992); Wellstein (1999).

> *conspector, dispector (despector), factitator, potentator, restitutor, resurrector, resuscitator, reuelator, salutifactor, sanctificator, suscitator, uiuificator; apparentia, impraescientia, improuidentia; factitamentum; factitatio, figulatio (18 nouns);*
> *inadprehensibilis, incongressibilis, incorporabilis, inconuertibilis, indemutabilis, informabilis, innascibilis, inreformabilis, nascibilis; corruptorius, incorruptorius, reuelatorius; monarchianus; substantiualis (14 adjectives);*
> *figulare*, *unare* (2 verbs).

Many of them are certainly *Augenblicksbildungen* (as Braun points out). More examples are cited in Wellstein (1999: 94), including interesting compounds such as *duricordia* or *munditenens*. On the whole, Tertullian's casual approach to coining new words provided much Christian Latin vocabulary and inspired some authors in the Middle Ages to behave similarly, although most Christian Latin authors did not go to such extremes, especially not the rhetorically minded Fathers like Lactantius or Augustine. Many of the post-classical words quoted in the appendix of this book are first attested in Tertullian.

In contrast to Tertullian, Aurelius Augustinus (354–430) did write scholarly works not directly concerned with Christian matters. Before his conversion to Christianity, he lived a rather worldly life as an orator, and he was clearly interested in learning in general.[30] Augustine treats the Liberal Arts in order to prepare for the one supreme science: theology. Already in his early dialogue *De ordine*, where he considers how order in the world comes about, he stresses the importance of these Liberal Arts (I.24, ed. Doignon, p. 126):

> *Nam eruditio disciplinarum liberalium modesta sane atque succincta et alacriores et perseuerantiores et commotiores exhibet amatores amplectendae ueritati, ut et ardentius adpetant et constantius insequantur et inhaereant postremo dulcius, quae uocatur, Licenti, beata uita.*
> 'For sober and mentally prepared study of the liberal sciences makes lovers of truth more alacritous, persevering, and passionate, so that they strive for and unwaveringly seek and finally cling more tenderly to, Licentius, what is called the blessed life.'

But later in his life, in his *Retractationes*, Augustine points out that Christian virtue is more important than scientific learning, which he came to believe he had overrated in his youth (I.3.2–4, ed. Knöll, pp. 19–20):

> *Verum et his libris displicet mihi [...] quod multum tribui liberalibus disciplinis, quas multi sancti multum nesciunt, quidam etiam sciunt et sancti non sunt.*
> 'Indeed, I dislike in these books [...] that I allotted much importance to the liberal sciences, which are unknown to many a saint, but others know them and are no saints.'

30 On Augustine's relation to worldly science, see Porro (2001: 130–133).

In his early period Augustine was strongly influenced by neo-Platonism, and he brought its way of thinking into Latin Christianity. In his youth, Augustine planned to write on all the Liberal Arts. He left a didactic dialogue, *De musica*, between a *magister* and a *discipulus* (a genre that was to be very successful in the Middle Ages), and an unfinished *De dialectica*.[31] This latter work is presented as a rather elementary introduction in simple style. It commences (ed. Pinborg, p. 83):

> *Dialectica est bene disputandi scientia. Disputamus autem utique verbis. Verba igitur aut simplicia sunt aut coniuncta.*
> 'Dialectics is the science of debating well. We debate with words. Words are either univocal or equivocal.'

Augustine's usual style is very different: in many of his works, a tension between the orator and the Christian preceptor who wants to be understood by simple and erudite people alike can be felt. Symptomatic of this is his statement (*Enarrationes in Psalmos* Ps. 36, sermo 3.6, ed. Dekkers & Fraipont, vol. 1, p. 371):

> *Melius in barbarismo nostro vos intelligitis, quam in nostra disertitudine uos deserti eritis.*
> 'It is better that you understand our barbarian way of talking than that you get lost in our erudition.'

This advice is formulated in a highly rhetorical manner with the word play *disertitudine [...] deserti eritis*. For Augustine's epistemology, the most important work is certainly *De doctrina christiana*. In this work (II, 13(20), ed. Green, pp. 46–47), while commenting on Psalm 32:12: *Beata gens, cuius est Dominus Deus eius* ('Happy the people whose Lord is its God'),[32] Augustine emphasises that a *sermo humilis* bordering on incorrect Latin syntax is not to be rejected in the context of the Bible. In the same work, he develops a philosophical theory of *signa*, a predecessor of modern semiotics. Although the primary aim is to teach biblical hermeneutics, his approach can be used quite generally. The first three books discuss *inventio* of what is to be understood, the fourth and final one its *modus proferendi* (I.1, ed. Green, p. 8). *Inventio* leads Augustine to the famous dictum (II.144–145, p. 75):

> *Philosophi autem qui vocantur, si qua forte vera et fidei nostrae accommodata dixerunt, maxime Platonici, non solum formidanda non sunt, sed ab eis etiam tamquam iniustis possessori-*

31 The introduction to the edition by Jackson convincingly shows by traditional and quantitative methods that the attribution to Augustine is very likely correct.
32 Stotz (forthcoming) writes that this passage is 'one of the *loci classici* in the discussion on faithful translation, *sermo humilis* and linguistic correctness'.

> *bus in usum nostrum vindicanda. [...]*[33] *sic doctrinae omnes gentilium non solum simulata et superstitiosa figmenta gravesque sarcinas supervacanei laboris habent quae unusquisque nostrum duce Christo de societate gentilium exiens debet abominari atque devitare, sed etiam liberales disciplinas usui veritatis aptiores.*
> 'The so-called philosophers, especially the Platonists – if perchance they say something true and conforming to our Faith, it is not only not to be feared, but it is to be appropriated as if from unlawful possessors. [...] thus, all teachings of the pagans not only contain counterfeited and superstitious figments and grave burdens of superfluous labour, which every one of us exiting from the company of the pagans, led by Christ, has to abhor and avoid, but there are also the Liberal Arts, which are rather apt for the use of finding truth.'

Like the pagan orator Quintilian, Augustine stresses the importance of general erudition, but he goes much further in his conception of an accomplished scholar; indeed, the following words could be used to describe much of the modern philological method (III.1, p. 79):

> *[...] praemunitus etiam scientia linguarum, ne in verbis locutionibusque ignotis haereat, praemunitus etiam cognitione quarumdam rerum necessariarum, ne vim naturamve earum quae propter similitudinem adhibentur ignoret, adiuvante etiam codicum veritate, quam sollers emendationis diligentia procuravit, veniat ita instructus ad ambigua scripturarum discutienda atque solvenda.*
> '[A man loving God and seeking to understand Scripture] should come fortified with the knowledge of languages [Hebrew, Greek], in order not to stick to unknown words and locutions; he should also come fortified with the knowledge of some necessary [historical and scientific] facts, in order not to miss the force and nature of things that are employed for their similarity [to something else]. In this, the truthfulness of the manuscripts will also help, which skilful care in emendation has taken care of. He should come thus instructed in order to discuss and solve the Scriptures' ambiguities.'

For Augustine *scientia* and *sapientia* are the higher goals of the mental *exercitatio* consisting of a Christian life and Christian studies.[34] Such 'science' has only limited common ground with 'worldly' science. Both Augustine's style and (ambiguous) approach to worldly science will become paradigmatic during the Middle Ages prior to the twelfth century. His influence on intellectual life in general in the Latin-speaking world can hardly be overestimated.

There are also some spurious surviving works that treat scientific matters – in particular, a shortened translation of Aristotle's *Categoriae* with important new vocabulary which, although not by Augustine, was probably written in his

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33 In between, Augustine 'proves' this point by quoting Exodus (3:21–22, 12:35–36) where God tells the Israelites to purloin from the Egyptians what is valuable.

34 Details in Cardelle de Hartmann (2018: 78–80).

time.[35] The translator often adds the Greek word to make sure his Latin terms are understood: *commutatio (id est ἀλλοίωσις)*.[36] The text was important in the Middle Ages as a logic primer. For instance, the Carolingian scholar Alcuin used it for his own *De dialectica*.

Augustine's contemporary Eusebius Sophronius Hieronymus (ca. 345–420), known as Jerome in English, is of interest in the present context mainly as the translator of the standard Latin Bible, in early modern times to be called the (*editio*) *vulgata*,[37] whose language was to become highly influential. He spent much of his life in the East and mastered Greek and Hebrew very thoroughly. This, together with an excellent Latin style, made him an ideal translator of the Bible into Latin and provided him with the basis for further scientific study, as Fürst (2016: 62) points out:

> eine gediegene Ausbildung, eine umfangreiche Bibliothek, ausgezeichnete Beziehungen zu einflussreichen Leuten vor allem in Rom sowie Sprachkenntnisse. Im Blick auf diese materialen Grundlagen theologischen Arbeitens ist Hieronymus als Wissenschaftler zu beschreiben, der einen vorrangigen Platz in der europäischen Wissenschaftsgeschichte beanspruchen darf.
> 'a solid education, an extensive library, excellent relations with influential people, especially in Rome, and language skills. In view of these material foundations for theological work, Jerome is to be considered a scientist who can claim a prominent place in the history of European science.'

Besides the Bible translation, he wrote many biblical commentaries and other scholarly works. Because of the Bible's holiness, Jerome, although convinced that *verbum de verbo* translation should in general be avoided, chose to translate in a rather verbatim manner (*Epistola* 57.5, ed. Labourt, vol. 3, p. 59):

> *Ego enim non solum fateor, sed libera uoce profiteor me in interpretatione Graecorum absque scripturis sanctis, ubi et uerborum ordo mysterium est, non uerbum de uerbo, sed sensum exprimere de sensu.*
> 'For I do not only admit but loudly proclaim that I do not formulate by the word-for-word method when translating from Greek (except for the Holy Scriptures, where even the order of the words is a mystery), but rather sense for sense.'[38]

Although he translated nearly the entire Bible text afresh – the Old Testament directly from the Hebrew – Jerome did not depart too far from the language of the

35 Thus Minio-Paluello in *Aristoteles Latinus* 1.1–5, p. lxxviii. The author may have been an otherwise unknown Albinus.
36 Ed. in *Aristoteles Latinus* 1.1–5, p. 174.
37 On biblical Latin in general, see Stotz (forthcoming).
38 More on his way of translating in Fürst (2016: 92–95).

earlier Latin translations, in order not to estrange Christians who were familiar with them.[39] Kaulen (1904) and Plater & White (1926) studied the Vulgate's language, which differs quite strongly from Classical Latin, and provide among other things lists of unusual vocabulary found in it. Many words with the suffixes *-tio* (*-sio*) *and -tor (-sor*)/*-trix*[40] are conspicuous. Some examples: *eruditor, exasperatrix, exquisitor, fornicator, habitatrix* (Kaulen 1904: 84). Kaulen found the following unusual true compounds: *circumpes, inauris, malogranatum, multiloquium, seminiverbius, stultiloquium, vaniloquium* (nouns; 97–98); *animaequus, cornupeta, falsiloquus, longanimis, manufactus, multigenus, multivolus, omnimodus, pusillanimus, quadrangulatus, triennis, unigenitus, versipellis* (adjectives; 151); *beneplacere, parvipendere, putrefieri, tapefacere, valefacere*, or even *pessimare* ('to make utterly bad') and *manicare* ('to come in the morning'; Luke 21:38) (verbs; 217–218). Of course, there are also many new words formed by suffixes, such as *ieiunatio* ('fasting'). Goelzer (1884: 130–134) lists further examples from other works of Jerome. There is a particularly large number of adjectives in *-alis* and *-bilis*. Of course, Greek words are quite common, and Hebrew ones occur as well, the latter mostly as proper names. Goelzer (14–15) tries to list Jerome's neologisms and arrives at some 350, although he admits that it is usually impossible to say with any certainty who first used a word.

Christian Latin comes from the speech of humble Christians and was from the very beginning consciously popular and anti-rhetorical, a *sermo piscatorius*. But from Tertullian onward, there are Christian authors with rhetorical pretensions, albeit different ones than those of the pagan writers. Mohrmann (1955: 21–23) described the new vocabulary of this 'langue de groupe'[41] and found three major types: new words for new Christian ideas and institutions (such as *apostata, apostolus, baptisma*); new abstract terms constructed following Greek models, often using suffixes (such as *carnalis, spiritualiter, incarnatio, revelator*); and new meanings for existing words (such as *fides, caro, spiritus*). This is the material with which Jerome worked. To some extent, this language drawn from life stands in conscious contrast to the rhetorical pagan Latin that early Christians will have seen as haughty, stiff, and dead. In several steps, Jerome improved existing Latin Bible translations, which were written in what might be called Christian spoken lower-class Latin. Although his result will have been less displeasing to an edu-

39 See Wick (2016) for more details.
40 See also Meershoek (1966) on this topic.
41 Around AD 180, Celsus already accused the Christians of ἀποτειχιζόντων ἑαυτοὺς καὶ ἀπορρηγνύντων ἀπὸ τῶν λοιπῶν ἀνθρώπων ('shutting themselves out and separating themselves from other people'; Λόγος ἀληθής 8.2, ed. Bader, p. 195).

cated reader, it is still far from rhetorical Latin. Jerome kept Hebrew and Greek terms that had become common among Christians, such as *sabatum, amen, cherubim, satan(as), alleluia, (h)osanna, zabaoth,* but he also translated some of them; thus, the Lord of Hosts usually becomes *dominus exercituum*, no longer *zabaoth*. Greek words are still common, for instance *apostolus, anathema, baptizare, blasphemare, clerus, diabolus, diaconus, ecclesia, elemosina, episcopus, evangelium, martyr, paracletus, presbyter, zizania*, and many more.[42] Latin words can have meanings unknown outside Christianity: *redemptor* ('contractor, undertaker, purveyor, farmer') comes to mean 'redeemer'; *saeculum* ('lifetime, race, age') becomes 'this world'; *oratio* ('speech') becomes 'prayer'; *aemulator* ('imitator') becomes 'zealot' (*Deus est aemulator;* Exod. 34:14), already attested in Tertullian; *lacus leonum* in Daniel 6:7 is a 'den, pit' not a 'lake, pond'. There are also syntactic Semitisms: Lot is Abraham's *frater,* here meant as 'relative' in general, in Genesis 14:16; *anima mea* stands quite often for mere *ego*, as in Hebrew *napši*; or *magis* plus adjective is used as a comparative. Cassiodorus was already aware of Jerome's importance for Christian Latin; he calls him *Latinae linguae multiplicator egregius* ('an eminent multiplier of the Latin language'; *Institutiones* I.5.4, ed. Mynors, p. 24). All the largely lower-class constituents of biblical Latin were thus ennobled and able to gain entrance into normal, written, 'fixed' Latin in all branches of life in the Middle Ages. Jerome's lasting influence on the Latin language was certainly a consequence of his Bible translation.

By Late Antiquity, translations from Greek had became important.[43] Whereas in late republican and early imperial times, knowledge of Greek among Roman intellectuals was taken for granted, this was already much less the case in the time of Quintilian. McGuire (1959: 4) pointed out that Romans had become much less intimate with Greek literature because they now had their own classics. After the watershed of the third century, knowledge of Greek became much rarer. Augustine's 'limitations in Greek were not exceptional, but were generally typical at the beginning of the fifth century' (15).[44] But the Latin language had progressively acquired much new terminology from Greek, all through Antiquity and in all intellectual fields. It has just been shown how strongly Christian Latin is indebted to

42 See further Stotz (1996–2004: IV, §§7–11 = vol. 1, pp. 519–542). In early modern times, some classicists, such as Sebastian Castellio (1515–1563), translate the Bible into Classical Latin without 'foreign' elements (see Stotz 2018).

43 Translations are listed in the ongoing *Catalogus translationum* (1960–) project. For a reasoned overview, see Berschin (1980: 105–108).

44 'There is no solid evidence for any real knowledge of Greek in Gaul after Sidonius and Gennadius [i.e. the end of the fifth century]' (McGuire 1959: 16).

Greek. McGuire (25) concludes that 'the West had assimilated profane and Christian Greek thought and learning to an amazing degree'. Many theological and exegetical works were translated, but not much specialist science. Conversely, translations from Latin to Greek remained rare in general, and only become more common in the later Middle Ages in the two centuries before the fall of Constantinople.[45]

Magnus Aurelius Cassiodorus Senator (ca. 485–ca. 585) can be seen as the founder of a paradigm of learning that proved to be stable and persistent, even in times of turmoil and war: the scholarly monk.[46] This new form of small cells of Roman culture within a world of barbarian migrations preserved enough Roman culture for it to be rekindled later on, as Brown (1987: 8) stressed:

> The monastery was a little world with a special culture all its own. Because it could expand to great numbers but also exist with very few, its culture was easily transplanted to a new cell in a new environment, where it could flourish independently, developing individual qualities and utilizing native talent.

After long pursuing in vain the idea of establishing a theological academy in Rome, Cassiodorus retired from his service at the court of the Gothic kings to found a monastery in Calabria called the Vivarium around 554. He gathered a significant library, and learned monks from the Greek East and the Latin West lived and studied there together. The monastery turned into a kind of theological university, apparently consciously imitating the Syrian school of Nisibis.[47] Although his monastery did not seem to survive its founder for long, the idea of erudite monks who lived in monasteries with well-stocked libraries was to take hold, and the monastic library became a key feature of Latin monasteries. Cassiodorus' interests covered both Christian and secular studies, especially grammar and dialectic; he was aware of the importance of translation, especially from Greek.[48] The

45 See Tinnefeld (2018).

46 There were some precedents. Strabo mentions monk-like scholars at the Alexandrian Museion: τὸ Μουσεῖον, ἔχον περίπατον καὶ ἐξέδραν καὶ οἶκον μέγαν, ἐν ᾧ τὸ συσσίτιον τῶν μετεχόντων τοῦ Μουσείου φιλολόγων ἀνδρῶν· ἔστι δὲ τῇ συνόδῳ ταύτῃ καὶ χρήματα κοινὰ καὶ ἱερεὺς ὁ ἐπὶ τῷ Μουσείῳ, τεταγμένος τότε μὲν ὑπὸ τῶν βασιλέων, νῦν δ' ὑπὸ Καίσαρος ('the Museion has a covered walk, a lecturing hall, and a big house in which the common room of the philologist members of the Museion is found. In this society, money is held in common and there is a priest for the Museion, back then designated by the Pharaoh, now by the Roman Emperor'; *Geographica* XVII.1.8, ed. Radt, vol. 4, p. 428).

47 On Syrian learning and Nisibis, see Becker (2006). The seminal work on this school is Vööbus (1965). But the interests of the Nisibis scholars were apparently exclusively theological.

48 Fögen (2016) studies his approaches to language and the human sciences.

influence of Augustine's approach to learning (see §2 above) is palpable in this quotation (*Institutiones* I.28.3, ed. Mynors, p. 70):[49]

> *Verumtamen nec illud Patres sanctissimi decreverunt, ut saecularium litterarum studia respuantur, quia non exinde minimum ad sacras Scripturas intellegendas sensus noster instruitur; [...] quanti enim philosophi haec solummodo lectitantes ad fontem sapientiae non venerunt, et vero lumine privati ignorantiae caecitate demersi sunt! quoniam, sicut a quodam dictum est, numquam potest plenissime investigari, quod non per viam suam quaeritur.*
> 'However, the most holy Fathers did not decree that secular studies be rejected, for out of them our understanding of the Holy Scriptures is furthered not little. [...] But how many philosophers who eagerly read them exclusively failed to reach the fount of wisdom and were deprived of the true Light and sunk into the blindness of ignorance? For, as someone [Aristotle?] has said, something can never be fully investigated if it is not done according to its own method.'

So, although the final method and path (*via*) to wisdom are only reached within Christianity, secular studies are nonetheless of great propaedeutic value. With a few exceptions, they were to retain this status until the twelfth century.

Latin neo-Platonism

§3 The influence of Greek neo-Platonism beyond what the Fathers had imported into Christianity is especially conspicuous in the following authors whose works have survived. Although an orator by profession, Marius Victorinus (ca. 285–ca. 365)[50] used a strikingly unrhetorical language that aims most strongly at precision. It would seem that he learned such a precise, matter-of-fact scientific style from Plotinus[51] (and other Greek authors) he translated. Unfortunately, his Plotinus translations did not reach the Middle Ages, and the Latin West had to wait until Ficino translated the *Enneads* into Latin again in the fifteenth century. Victori-

49 Indeed, the subsequent paragraph quotes *De doctrina christiana* II.61(62), ed. Green, pp. 76–77.

50 On Marius Victorinus, see Hadot (1971).

51 Norden remarks regarding Plotinus' style that he is often careless ('Gesprächston', 'conversational tone'), but not always, for on occasion: 'Da erhebt sich dann seine Sprache, dem Gegenstand folgend, oft zu einer nur mit Platon vergleichbaren Grandiosität, so wenn er über das Schöne spricht, wenn er die Vollendung der Welt und die Güte des Schöpfers gegen die Gnostiker verteidigt, wenn er das selige Schauen an dem überhimmlischen Ort schildert, ὡς οἷόν τε τὰ τοιαῦτα εἰπεῖν (V, 8,1)' ('Then his language, following its object, often rises to a grandiosity comparable only to Plato's, for instance when he talks about beauty, when he defends the perfection of the world and the goodness of the Creator against the Gnostics, when he describes the blessed contemplation in the super-celestial place, "as far as it is possible to say such things" (V.8.1)'; 1958: 1:400).

nus also translated some works by Aristotle, but his translations were largely superseded by Boethius (see §6 below), who used a similarly precise Latin style that was to become the seedbed for scholastic Latin. Von Albrecht praises Victorinus as follows: 'Mit ihm erreicht die lateinische Sprache jene Exaktheit, die ihr in philosophischen Dingen lange fehlte' ('With him, the Latin language reaches that exactness which it had long lacked in philosophical matters'; 1992–1994: 2:1284) On the other hand, this precise, terse style was perceived as obscure by Jerome (*De viris illustribus* 101, ed. Richardson & von Gebhardt, p. 48):

> *Victorinus, natione Afer, Romae sub Constantio principe rhetoricam docuit et in extrema senectute Christi se tradens fidei scripsit Adversus Arium libros more dialectico valde obscuros, qui nisi ab eruditis non intelliguntur, et commentarios In apostolum.*
> 'Victorinus by origin an African, taught rhetoric in Rome in the time of Constantius [II]. In extreme age converted to the Christian faith, he wrote very obscure books against Arius in a dialectical style which can only be understood by the erudite, and Pauline commentaries.'

Augustine tells us that he read some of Victorinus' translations.[52] The latter's *De definitionibus* considers what can pass as a definition: he describes fifteen different types, but the list is not intended as exhaustive (*De definitionibus* 29, ed. Pronay, p. 79):

> *Sunt et aliae fortasse species definitionum; verum si quis invenerit, adiciat numerum.*
> 'There may also be further kinds of definitions; in fact, if someone finds one, let him add it.'

This openness may be seen as scientific, although it must be said that except for the first (definition by something's essence) these kinds of definitions would hardly have been acceptable as more than first attempts for, say, Aristotle. Hadot (1971: 163) believed that Victorinus followed a lost Greek treatise, as the names of the kinds of definitions are all Greek. Such a treatise, if it did exist, will hardly have been by Porphyrius (Pronay, edition, p. 21), contrary to what Hadot had believed possible. A sample from *De definitionibus* (17, ed. Pronay, p. 67) will illustrate his language:

> *Secunda est quae dicitur ἐννοηματική, quam notionem communi, non proprio nomine possumus dicere. In omnibus enim reliquis definitionibus notio rei profertur, non substantialis explicatio declaratur, verum haec quae secunda est hoc modo semper efficitur, cum, proposito eo quod definiendum est neque dicto eius genere, verbis in rei sensum ducentibus audientem quid illud sit de quo quaeritur explicatur.*

52 *Confessiones* VIII.3, ed. Verheijen, pp. 114–115.

'The second kind of definition is called ἐννοηματική. We can call this a notion acquired by a general not proper name. In all other [except the first, treated prior to the quotation] definitions a notion of a thing is mentioned, not an explanation of its essence given. In fact, this second kind is always constructed in this way, as explaining what the *definiens* that is sought is, after proposing what it is, but without mentioning its genus [which is what the first kind of defining does], with words that lead the interlocutor to the meaning of the thing to be defined.'

This precise but complicated style looks like a cross between Cicero and the later university scholastics. In fact, besides Greek authors, Marius quotes Cicero often and with praising adjectives, in *De definitionibus* especially the *Topica* and *De inventione*. The innovative terminology in Marius Victorinus includes terms such as *exsistentia, essentialis, consubstantialis, praeprincipium, praeviventia*. Springhetti, who lists these and other examples, concludes (*Latinitas fontium*, p. 28):

Merito igitur Victorinus, utpote initiator propriae terminologiae philosophicae latinae, inter 'Medii Aevi conditores' adscribendus est.
'Thus Victorinus is rightly counted among the "founders of the Middle Ages" inasmuch as he is the initiator of proper philosophical terminology in Latin.'

Hardly anything is known about Calcidius, who may have written in fourth-century Hispania. He translated Plato's only work on natural philosophy, the *Timaeus*, and included a Greek-style, scientific commentary on it, which focuses on mathematics and astronomy. His vocabulary is equally innovative, for example *conceptim, intermanare, silva, noys*.[53] Sometimes he can be observed consciously trying to map Greek terms onto Latin (ed. Waszink, p. 251):

Idem aiunt uidere nos uel tuitione, quam phasin uocant, uel intuitione, quam emphasin appellant, uel detuitione, quam paraphasin nominant.
'[The geometers] say that we see either by direct vision, called φάσις [apparition] in Greek, or reflected vision, called ἔμφασις [reflection] in Greek, or opaquely translucent vision, called παράφασις [?].'[54]

Thus, corresponding Latin prefixes are used to duplicate Greek terminology from optics. The translations are based on *tueor* = φαίνομαι. In this case, the new Latin terms were not successful. The term παράφασις is not known from other extant sources on optics. This text was to become very influential among twelfth-century Platonists in particular.

53 See Dronke (2008: 8–12).
54 My glosses of the Greek words follow the explanations by Calcidius right after this excerpt.

A further important neo-Platonist Latin author was Ambrosius Theodosius Macrobius (fl. ca. 400), who wrote a commentary on Cicero's *Somnium Scipionis* (thereby preserving this lost part of Cicero's *De re publica*). The commentary stands in the tradition of advanced Greek scientific commentaries and was influential in the Middle Ages.[55] These authors, together with Martianus (§5) and Boethius (§6), provided the twelfth-century Platonists with their best sources of information about Greek Platonism.

The study of Latin

§4 Toward the end of Antiquity, there are a surprising number of surviving Latin grammatical texts.[56] Most of them are clearly intended for school use, and are not meant as scientific studies of language. Usually, very little about the authors is known, and they tend to copy much from one another. Ultimately, their grammatical approach goes back to Hellenistic Greek grammar, which had been framed by the Stoics as a descriptive science.[57] In Late Antiquity, grammar becomes part of school teaching and petrified as a dogmatic structure, losing its research nature. The grammarians Aelius Donatus (fl. ca. 350) and Priscian (fl. ca. 500) are the two most influential ones for the centuries to come. We take a brief look at the former here. Little is known about him, apart from the fact that, apparently, he was Jerome's teacher[58] and thus flourished in the middle of the fourth century. He wrote an *Ars maior* and an *Ars minor* for beginners. His more advanced grammar is very systematic, though still at a rather elementary level and not at all original. Grammatical categories are named, sometimes defined, subcategories are introduced, and usually examples are given. But the content is not treated organically, and no unclear points are discussed: the work resembles more a list of things to be learned by pupils or an inventory.[59] As an example, consider *Ars maior* II.1, ed. Holtz, p. 613:[60]

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55 See Schedler (1916); see also the edition of Macrobius by Armisen-Marchetti.
56 See the online collection Corpus Grammaticorum Latinorum (http://kaali.linguist.jussieu.fr/CGL/index.jsp) by Alessandro Garcea, which includes over one hundred texts. They can also be searched on Corpus Corporum.
57 See Holtz (Donatus edition, pp. 3–11).
58 Jerome, *Contra Rufinum* I.16, ed. Lardet, p. 46.
59 More details on the work's form can be found in the edition by Holtz, pp. 49–52. See Leonhardt (2013: 97) on the importance of Donatus.
60 The canon of these eight parts of speech has lived on with few changes until recently. The main change in what has become the standard system is that adjectives take the place of participles. Practically the same system will be used in our corpus studies below (chap. 18).

> *partes orationis sunt octo, nomen, pronomen, uerbum, aduerbium, participium, coniunctio, praepositio, interiectio. ex his duae sunt principales partes orationis, nomen et uerbum. Latini articulum non adnumerant, Graeci interiectionem. multi plures, multi pauciores partes orationis putant. uerum ex omnibus tres sunt, quae sex casibus inflectuntur, nomen, pronomen et participium.*
> ‘There are eight parts of speech: noun, pronoun, verb, adverb, participle, conjunction, preposition, interjection. Among these, two are the main parts of speech: noun and verb. The Latins do not count the article, the Greeks the interjection. Many posit more, many fewer parts of speech. There are three of them that are inflected, in six cases: noun, pronoun, and participle.’

Holtz (edition, p. 56, quoting Fuhrmann 1960) shows that this kind of technical inventory style is a development of fourth-century-BC Hellenism. Greek technical vocabulary had long since been translated into and adapted to Latin, and was in many cases to remain in use into the present day. Similar dispositions of facts and a similar unrhetorical style are encountered in many of the following manuals.

§5 In this ‘age of résumés’, the one that had the greatest impact on the Middle Ages was written by Martianus Capella, most likely between 410 and 439, in an allegorical, neo-Platonist coating: the prosimetrum *De nuptiis Philologiae et Mercurii*. It introduced the Seven Arts to mediaeval readers; the work began to be used as a schoolbook in Carolingian times and became very popular. His difficult and often obscure style led to several Carolingian commentaries, as well as to a philological reworking of the text, as can be seen from the existence of a Carolingian vulgate text that introduced many conjectures, some of them still retained in modern critical editions.[61] Stahl (1971: 1:30) is certainly right when he claims ‘it would be hard to find a Latin author with a more unusual vocabulary’. He differentiates two groups of neologisms: bold compounds and technical or scholarly words (often Greek). One can get an impression of this from a list of Georges entries attested only for Martianus. They number nearly two hundred (excluding proper names and epithets of divinities); a–d are listed here:

> *abdicative; adiaculatus; adoperte; aequicrurius; agalma; aggarrio; agoge; anacamptos; animator, -oris; antemeridialis; antipodus; antisagoge; arhythmos; asomatus; assecutor, -oris; assertum; astrifico; astriloquus; asynthetus; autumnasco; balteo; blandificus; bupaes; calymma; carians; cernentia; collema; colorabilis; compositivus; concussus; conexe; conspicabundus; contigue; conubialiter; culmino; cunctalis; cuncticinus; curvatio; declarative; decretio;*

61 On the complicated textual tradition, see Shanzer (1986), and Guillaumin in the introduction of his edition of book IX.

dedicative; deluctatio; demerso; dendrites; desorbeo; diastematicus; dilophos; directilineus; discussius; disemus; disgregus; diversicolor, -oris; dulcinervis; dysprophoron.[62]

As usual, it is impossible to guess how much of this was really coined by Martianus and how much was already in circulation but does not happen to be found in the surviving sources. Some of the words are merely Greek in Latin letters (underlined, in total 46 of 186), some are attempts to imitate Greek (such as *colorabilis* for χρωματικός),[63] but most are Latin suffix constructions and compounds, as Martianus himself states in the next quotation. In general, Martianus is hardly less afraid to coin new terms than the most extreme Greek authors, such as Democritus; for instance, he uses some rather daring compounds in order to name climate zones by means of standard places (e.g. διὰ Ἀλεξανδρείας becomes *diaalexandrias*). Martianus is conscious of the process of linguistic innovation (*De nuptiis Philologiae et Mercurii* V, §510, ed. Willis, p. 176):

> *quod si qua res propria verba non habeat, novanda sunt aut alienis utendum. novantur autem duobus modis verba: aut quadam fictione aut declinatione praesumpta, aut duorum, quae usitata sint, coniunctione composita. finguntur maxime cum transferimus, ut qui poeotetas 'qualitates' esse dixerunt, quod nomen numquam fuerat in Latinis. ‹in› quo et auribus temperandum et insolentia fugienda. quam vitans Cicero soterem 'salvatorem' noluit nominare et ait 'qui salutem dedit'; illud enim nimis insolens videbatur.*
> 'That if some thing does not have its own designation, words have to be created or words from other areas have to be used. They can be created in two ways: either taken up through invention or derivation, or compounded by juxtaposition of two current ones. They are most often coined when we translate: as when people said *qualitates* for ποιότητες, a word that had not existed in Latin. When doing this, one should be temperate with the ears [of listeners] and shun extravagance. Avoiding which, Cicero did not want to call σωτήρ *salvator* and said *qui salutem dedit*, the former seeming too extravagant to him.'

Martianus' open linguistic approach becomes even clearer in IV, §379, ed. Ferré, p. 30, where he states that one should not be afraid to complete missing paradigms: if one can say *pinna* ('wing') and *pinnatus* ('winged'), why not derive a word from *pes* ('foot') meaning 'footed'?[64] Martianus' novel language, though similar to Tertullian's in boldly using obscure or new terminology, is yet of a somewhat different kind. Much of the text's considerable difficulty lies in his often very

62 Compare this list with Stahl's study of this topic in an appendix (1971: 250–252).
63 Martianus apologises for the word in the usual manner with *chromatice, quam nos vix forsan recte colorabilem memoramus* ('χρωματική, which we perhaps hardly correctly mention as *colorabilis*'; IX, §942, ed. Guillaumin, p. 41).
64 Compare chap. 12 §5 below on Raimundus Lullus, who will go very far in this direction.

artificial and deliberately ambiguous syntax.[65] Martianus certainly knew Apuleius,[66] and seems to try to imitate him and to exaggerate his non-classical tendencies even more.

Martianus occasionally insinuates that the scientific studies he describes in his work are more apt to the Greek, for example when *Geometria* says: *Romuleis ut potero uocibus intimabo* ('I will say it in Roman words as far as I can'; VI, §587, ed. Ferré, p. 8). He sees the mathematical sciences in particular as Greek and hard to express in Latin. As he indeed often uses Greek terms, this does not seem to be a mere topos for him. He invokes Athena as follows (VI, §574, ed. Ferré, p. 3):

> *O sacra doctarum prudentia fontigenarum,*
> *sola novem complens, Musis mens omnibus una,*
> *deprecor: ad proprium dignata illabere munus*
> *inspirans nobis Graias Latiariter artes.*
> 'O sacred wisdom of the learnèd Muses born at the fountain, thou alone makest up the nine, one mind to them all, thee I beseech, deign to bestow thy proper gift, inspiring us to teach the Greek arts in a Latinate manner.'

In passing, he seems to allude to a scientific method applicable 'to all arts', formulated for astronomers (III, §230, ed. Willis, p. 62):

> *[...] et astronomus quaedam facit, ut per ea cognoscat, quae debeat comprobare.*
> '[...] as the astronomer does certain things in order to understand with the help of them what he has to prove.

Nevertheless, it would seem that Martianus misunderstood quite a few of the more difficult technical details, especially in the *quadrivium*,[67] but in some fields,

65 This special style was abhorred by Ciceronian classicist scholars. Schanz & Hosius call it 'widerlich' ('revolting') and remark that 'die Geschmacklosigkeit durchdringt das ganze Werk' ('bad taste permeates the entire work'; 1922–1935: 4.2:168). Lemoine (1972) tried to evaluate Martianus' style without Ciceronian prejudice. It would seem to me that Martianus' style does have its own kind of considerable beauty and elegance.

66 There are quite a few words known only from these two authors in Antiquity (according to Georges), such as *infinibilis* ('infinite'), *capillitium* ('hair'), *colliculus* ('little hill'), *declarativus* ('explanatory'), *nuptu(r)ire* ('to wish to marry'), *pluriformis* ('of many shapes'), *praediatus* ('wealthy'), *reflexim* ('conversely'), *susurramen* ('murmur'), *ultramundanus* ('beyond the world'), *undanter* ('in a waving manner').

67 Instances can be found in Stahl's detailed commentary (Stahl & Johnson 1971). For example, in VI, §§597–598, Martianus does not understand Eratosthenes' measurement of the Earth's circumference, but according to Stahl no Latin writer in Antiquity did. VIII, §876 claims that the summer tropic passes though Meroe, when it actually passes through Syene; and in VII, §756 Martianus seems to fall short in basic arithmetic.

such as harmonics and metrics,[68] he does seem to be at the height of what was then possible.

§6 As the knowledge of Greek was disappearing toward the end of the Western Roman Empire,[69] more translations are made, but few of them have come down to us (or even the Middle Ages). An exception to this dearth of Greek thought in the Middle Ages is theology (including Church history). Many important Greek Church Fathers were translated, especially by Rufinus of Aquileia, who translated works by Basilius, Origen, Gregory of Nazianzus, Eusebius, and Pamphilus.[70] But the more theoretical Greek sciences were still hardly translated at all; the translations by Anicius Manlius Severinus Boethius (ca. 480–524), especially of Aristotelian works, are the one great exception, with far-reaching consequences.[71] He was to be praised as *maximus latinorum philosophorum* ('the greatest of the Latin philosophers').[72] He had realised that it was necessary to save as much Greek knowledge as possible by transplanting it into the Latin language. Although real reading knowledge of Greek was indeed to remain very rare in the Latin Middle Ages (until the Italian Renaissance in the fifteenth century), Greek culture and its language always remained prestigious; in fact, many authors used 'ornamental Greek' – some Greek words here and there to playfully adorn their texts, possibly also to show off their erudition.[73]

Boethius' translations of the Aristotelian *Organon* (except of the *Analytica posteriora*), together with commentaries, were to become the basic texts for learning logic throughout the Middle Ages, later known as the *logica vetus*. Besides this, his works on the *quadrivium* were equally influential, especially *De arithmetica* and *De musica*; his treatises on geometry and astronomy have been lost but did enjoy some influence.[74] Boethius also mentions a work he apparently wrote

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68 Maritianus also wrote a brief work on metre that has recently been rediscovered. A provisional edition can be read in Guillaumin (2008). The text was discovered by de Nonno (1990), who promised but failed to deliver an edition.

69 On Greek in the Latin Middle Ages, see Bischoff (1951), then Berschin (1980).

70 On Rufinus, see Murphy (1945); on his translation style, see Marti (1974: 91–92).

71 We encountered Calcidius' translation of the *Timaeus* above, and medical works were also translated, e.g. Dioscurides' *De materia medica* in the sixth century.

72 Abelard, *Theologia christiana* I.134, ed. Buytaert, p. 129, calls him thus, although he also uses this epithet for Cicero (*Introductio ad theologiam* PL 178.1087C).

73 This very fitting term, *ornamentales Griechisch*, was proposed by Berschin; on this topic, see Stotz (2011). It is contrasted to 'terminological Greek' (borrowings with a scientific or liturgical function). The most avid users of ornamental Greek in the Early Middle Ages were the Irish.

74 See Gruber (2011: 24–25), with references.

on physics, but nothing further is known about it.[75] His *De arithmetica* (mostly a translation of Nicomachus of Gerasa) was to become the basic text on the subject in the Middle Ages. It states (I.1, ed. Oosthout & Schilling, p. 9):

> *Est enim sapientia rerum, quae sunt suique immutabilem substantiam sortiuntur, comprehensio ueritatis.*
> 'For wisdom is the truthful understanding of the things that exist and that have their own unchanging substance.'

Here Boethius is using *sapientia* for 'science'.[76] In his theological works, Boethius stresses the importance of *ratio* alongside *auctoritas*; indeed, he hardly cites authorities and makes very broad use of reasoning. For his approach to theology and his emphasis of logic Boethius is often rightly considered the father of scholasticism (or the 'last Roman and first scholastic'; Grabmann 1957: 1:148), although his methodology was not to find much imitation until half a millennium later. He decided that the ideal of a most faithful translator (*fidus interpres*)[77] should be adopted for scientific works when translating from Greek. This resulted in a *verbum de verbo* translation,[78] a kind of Greek in Latin words, as we have already encountered above in Jerome's Vulgate. Boethius puts this very similarly (*In Porphyrium* I.1, ed. Brandt, p. 135):[79]

> *vereor ne subierim fidi interpretis culpam, cum verbum verbo expressum comparatumque reddiderim. Cuius incepti ratio est quod in his scriptis in quibus rerum cognitio quaeritur, non luculentae orationis lepos, sed incorrupta veritas exprimenda est.*
> 'I fear I will suffer the blame of the faithful translator because I render each word by one and the same word. The reason for this undertaking is that in writings in which knowledge of things is sought, not the beauty of distinguished oratory but the uncorrupted truth is to be expressed.'

75 Boethius, *In librum De interpretatione Aristotelis maior* III.9, ed. Meiser, p. 190: *sed quoniam tres supra modos proposuimus contingentis, de quibus melius in physicis tractavimus, singulorum subdamus exempla* ('but as we have above proposed three modes of contingency, which we treated better in *De physicis,* we shall provide examples for each').

76 Boethius shortened the thought of Nicomachus, who had written: καὶ ταύτην δὲ τὴν σοφίαν ‹Πυθαγόρας› ὡρίζετο ἐπιστήμην τῆς ἐν τοῖς οὖσιν ἀληθείας, ἐπιστήμην μὲν οἰόμενος εἶναι κατάληψιν τοῦ ὑποκειμένου ἄπταιστον καὶ ἀμετακίνητον, ὄντα δὲ τὰ κατὰ τὰ αὐτὰ καὶ ὡσαύτως ἀεὶ διατελοῦντα ἐν τῷ κόσμῳ καὶ οὐδέποτε τοῦ εἶναι ἐξιστάμενα οὐδὲ ἐπὶ βραχύ ('But ‹Pythagoras› defined wisdom as knowledge/science of the truth in what is, conceiving "science" as the infallible and unchangeable apprehension of the underlying being, and "what is" to be what persists always uniformly and the same way in the world and that never departs from being, not even for a brief moment'; *Introductio arithmetica* I.1.2, ed. Hoche, p. 2).

77 See further Ebbesen (2009: 38–42); Schwarz (1985); Marti (1974: 87–89).

78 On this technique, see Marti (1974: 64–81).

79 On his translation style, see Vogel (2016: 131–144).

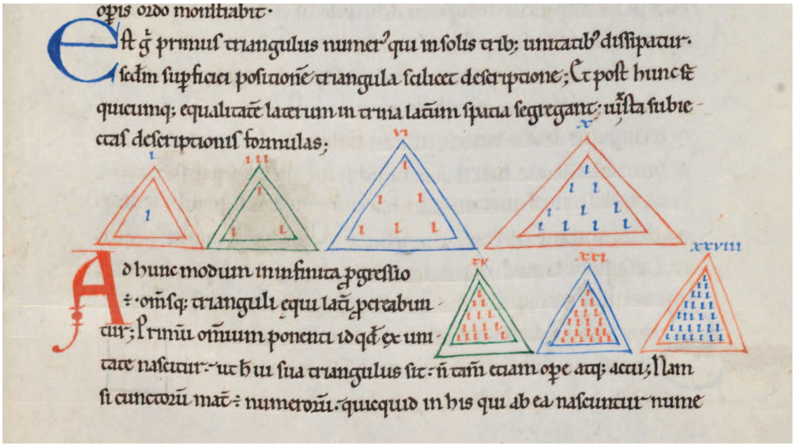

Fig. 14: A diagram explaining triangular numbers from Boethius, *De arithmetica* II.7. In modern notation they equal $n(n+1)/2$ for $n \in \mathbb{N} = 1, 3, 6, 10, 15, 21, 28$, etc. St. Gallen, Kantonsbibliothek, Vadianische Sammlung 296, fol. 26r. Reproduced with permission.
Source: https://www.e-codices.unifr.ch/en/list/one/vad/0296.

Obviously, Boethius was an author capable of using very different styles for different purposes: his scientific writings are stylistically very different from his brilliant *Consolatio philosophiae*, which also includes some remarkable poetry. At the other end of the spectrum, Boethius wrote two commentaries on Porphyry's *Isagoge*. This introductory text also became part of the mediaeval *logica vetus* and was much read, albeit mostly in the guise of Boethius' translation alone, without the commentaries. Thirty-four and twenty-one manuscripts are known of two commentaries respectively (Gruber 2011: 31). In contrast to the shorter first commentary, which is a didactic dialogue in the Ciceronian tradition, the second, in 'wissenschaftlich-technische Fachsprache' (Gruber 2011: 30–31), is meant for more advanced readers. Content-wise, Brandt concludes that the two commentaries differ little.[80] Whereas the first commentary used the translation by Marius Victorinus (lost, except in the commentary), Boethius made a fresh, very verbatim one for the second commentary. He himself puts it thus (*In Porphyrium* II.1.7, ed. Brandt, p. 154):

> *ut in prima editione dictum est, hanc expositionem nostro reseruasse iudicio, ut ad intellegentiam simplicem huius libri editio prima sufficiat, ad interiorem uero speculationem confirmatis paene iam scientia nec in singulis uocabulis rerum haerentibus haec posterior colloquatur.*

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80 *Sed uere discrepare inter se duos commentarios non repperi* ('But I did not find the two commentaries to differ substantially'; edition, p. xxi).

> 'as was announced in the first commentary, this exposition was kept back by our judgement so that for a simple understanding the first commentary on this book suffices, but for deeper thinking on the part of those who are already advanced in this science and do not stumble on single words, these following matters will be discussed.'

A comparison of a random passage in the two commentaries is given below, commenting on Porphyry's statement Διαφορὰ δὲ κοινῶς τε καὶ ἰδίως καὶ ἰδιαίτατα λεγέσθω ('Difference is said in a common, in a special, and in a most special way'; *Isagoge*, ed. Busse, p. 8). Page numbers from Brandt's edition are given in parentheses; Brandt marks translated text with *Sperrdruck*.

Editio prima

(85) Hic Fabius: Uberrime. inquit, a te hesternis uigiliis de generibus et speciebus expositum est. sed, ut dici audio, subtilior de differentiis tenuiorque tractatus est. – Non. inquam, inmerito. nam uarie acceptae differentiae uarias habebunt etiam potestates. erunt namque alias genera, alias species, alias uero differentiae. sed hoc postea demonstrabitur, nunc uero ita, ut arbitror, textus est: Omnis differentia et communiter et proprie et magis proprie dicitur. Differentiam quoque multis modis appellari designat. dicit autem tribus his modis fieri differentiam, cum aut communes sunt aut propriae aut magis propriae. communes sunt quibus omnes aut ab aliis differimus aut a nobis ipsis. nam sedere uel ambulare uel stare differentia est; nam si tu ambules, ego uero sedeam, in situ ipso atque ambulatione differimus. et item ego cum nunc sedeo, postea uero si ambulem, communi a me ipso differentia discrepabo. propriae uero sunt (86) quae unius cuiusque indiuidui

Editio secunda

Differentia uero communiter et proprie et magis (240) proprie dicitur. [...]
Tribus modis aliud ab alio distare praediximus, genere, specie, numero, in quibus omnibus aut secundum substantiales quasdam differentias alia res distat ab alia aut secundum accidentes. nam quae genere uel specie distant, substantialibus quibusdam differentiis disgregata sunt, idcirco quoniam genera et species quibusdam differentiis informantur. nam quod homo ab arbore genere distat, animalis sensibilis qualitas in eo differentiam facit. addita enim sensibilis qualitas (241) animato animal facit, eidem detracta facit animatum atque insensibile, quod uirgulta sunt. igitur homo atque arbor genere differunt – utraque enim sub animalis genere poni non possunt –, differentia sensibili secundum genus discrepant, quae unius ex propositis tantum genus, id est hominis informat, ut dictum est. illa uero quae specie distant manifestum est quod ipsa quoque differentiis

formam aliqua naturali proprietate depingunt, ut si quis sit caecis oculis uel crispo capillo; etenim propria unius cuiusque singuli hominis sunt quoquo modo ista nascuntur.	*substantialibus discrepant, ut homo atque equus differentiis substantialibus discrepant, rationabilitate atque inrationabilitate. ea uero quae indiuidua sunt et solo numero discrepant, solis accidentibus distant.*

The dialogue form of the first commentary accounts for some obvious differences: the style is more personal, less 'abstract'. But the second commentary also clearly uses a more specific terminology: *accidentes, sensibilis qualitas, informat*. The second commentary is longer (37,000 vs 26,000 words), but the vocabulary also seems to be somewhat richer.[81] The words that are only found in the second commentary include technical terms like *adventicius, absolutus, accidentalis, adaequatio, alteritas*. Gruber (2011: 31) further observes what he calls typically scholastic syntax (like *dico quoniam*) and vocabulary (*specificus, subiectum, praedicatum*). This second commentary can be seen as the ancestor of scholastic Latin (see chap. 11).[82] Much new Latin vocabulary goes back to Boethius, especially in logical Aristotelian terminology,[83] and was to remain very stable throughout the lifespan of Latin.

It is interesting to note in passing that Sergius of Rēšʿainā (d. 536) fulfilled a very similar rôle in salvaging Greek logic for the Syriac language to what Boethius did for Latin.[84] He also translated the *Organon* and Porphyry's *Isagoge*. It would in general be interesting to compare the appropriation of Greek science in Latin and Syriac/Arabic.

§7 Visigothic *Hispania* enjoyed a *Nachblüte* of Roman culture in the sixth and seventh centuries. In this flourishing post-Roman culture, important scholarly texts were written on history, grammar, and law (such as the *Lex Visigothorum*, ca. 654), as well as encyclopaedias.[85] Latin culture eventually came to an abrupt halt through the Muslim invasion of the Iberian peninsula (beginning in 711); after this, Arabic culture was to flourish here, possibly more than anywhere else in the

81 1,003 lemmata are used in both commentaries (according to Corpus Corporum), in total somewhat more in the second (1,836; 1,693 if shortened to the length of the first commentary) than in the first (1,608).
82 See Smith (1925).
83 Gruber (2011: 101); Roelli (2014a: 950–954).
84 See Hugonnard-Roche (2004).
85 There is a list of the writers in this *Nachblüte* in Díaz y Díaz, *Index scriptorum latinorum medii aevi hispanorum*.

ensuing centuries, but to the detriment of Latin culture. We shall take a brief look at the most important encyclopaedist of the Middle Ages here: Isidore of Seville (ca. 560–636). Especially his *Etymologiae* were immensely successful; more than a thousand manuscripts are known.[86] The study of his sources is by far not complete, but it is clear that Isidore used material from many authors, probably often through florilegia, much more often pagan than Christian ones.[87] Similarly to Varro in his *De lingua latina*, but on a much grander scale and organised into scientific fields, Isidore treats the semantic, 'etymological' webs of things. His twenty books treat the following subjects (see Díaz y Díaz, in the Oroz Reta & Marcos Casquero edition, p. 174):

- book I: *grammatica* – linguistics, grammar,
- book II: *rhetorica et dialectica* – oratory and logic,
- book III: *mathematica* – the *quadrivium*,
- book IV: *medicina* – medicine,
- book V: *leges et tempora* – jurisprudence and a world chronology,
- books VI–VIII: theology,
- book IX: *linguae*, *gentes*, *regna*, etc. – history and human geography,
- book X: *vocabula* – an alphabetical list of words and their webs of meaning (*etymologiae*),
- book XI–XII: *homo*, *animalia* – biology,
- books XIII–XIV: *mundus*, *terra* – physical geography,
- book XV: engineering,
- book XVI: *lapides et metalla* – studying solid bodies,
- book XVII: agriculture,
- book XVIII: war tactics,
- books XIX–XX: household tools.

This covers much more than the Liberal Arts (covered in books I–III) and, indeed, even more than 'science' as defined above; the last few books, in particular, seem to move toward a general treatment of human culture.[88] Of course, Isidore knows the Seven Arts (I.2, ed. Lindsay), but he also knows other classifications of philosophy, such as that into *ethica*, *physica*, and *logica* (II.24.3, ed. Marshall, p. 103). Samples of Isidore's clear and rather plain Latin have already been quoted above

86 Díaz y Díaz, in the Oroz Reta & Marcos Casquero edition, p. 200, quoting Anspach (1966).
87 On the sources, see Díaz y Díaz, in the Oroz Reta & Marcos Casquero edition, pp. 189–200. On the work, its genesis, and importance, see Fontaine (2000).
88 Admittedly, however, the first half of the work (containing the *artes*) is more commonly found in the manuscripts (see Beeson 1913: 83). This long work was often transmitted in two volumes, and these not always together.

(chap. 2 §4, chap. 3 §§3, 8). As he himself puts it while speaking about rhetoric (*Etymologiae* II.16.1–2, ed. Marshall, p. 65):

> *Latine autem et perspicue loquendum. Latine autem loquitur, qui uerba rerum uera et naturalia persequitur, nec a sermone atque cultu praesentis temporis discrepat. Huic non sit satis uidere quid dicat, nisi id quoque aperte et suauiter dicere; ne id quidem tantum, nisi id quod dicat et facere.*
> 'One has to speak in Latin [as distinct from the vernacular *lingua rustica*] and in a clear manner. Someone speaks Latin if he sticks to the words for things that are genuine and natural, does not depart from the way of speaking and the practice of his time. For him, it is not enough to see what to say, he must also say it clearly and gracefully; and not only this, but he must also practise what he speaks about.'

Despite this, Isidore uses quite a lot of unusual Latin words, but in stark contrast to writers such as Apuleius, Tertullian, or Martianus Capella, in his case these words are nearly always names for *realia* that he explains. Some examples:[89]

> *Genera lacertorum plura, ut botrax, salamandra, saura, stellio.*
> 'The kinds of reptiles, such as *botrax*, salamander, lizards, newts.'

Among these, *botrax* is not otherwise known and may be a vulgar form of βάτραχος ('frog'). There are many similar instances. Isidore often seems to have drawn on colloquial sources. Such unusual words are mostly nouns, but not only: XIX.28.8 (ed. Rodríguez-Pantoja, p. 239) knows a colour *blabus* ('blue'?) and another *mesticium* ('mixed'?).[90] More examples will be examined below (chap. 21 §3), such as *sarna*, which seems to be an autochthonous Hispanic term for the disease impetigo.

Isidore's differentiation between *ars* and *disciplina*/*scientia* was to remain common ground for the times that followed (*Etymologiae* I.1.3, ed. Lindsay, quoted in Latin in chap. 3 §3 above):

> Between *ars* and *disciplina* Plato and Aristotle would posit the distinction that *ars* is about things that can also be different, but *disciplina* is about things that cannot turn out differently. So, when something is studied using true arguments it will be a *disciplina*, when it is treated in a manner [only] resembling truth and open to opinion, it will have the name *ars*.

Now, after what has been said above (chap. 7 §5), this statement is at least a considerable simplification. Aristotle was aware that ἐπιστήμη (*disciplina*) should not only cover events that cannot turn out differently, but should also cover those that happen only for the most part. If one uses Isidore's strict division, only the fields

89 From *Etymologiae* XII.4.34, ed. André, p. 161. See Sofer (1930: 103).
90 See Sofer (1930: 108).

of the *quadrivium* will remain *disciplinae;* most of the topics of his *Etymologiae* will then be *artes*. As has been mentioned (§5), this point of view fits Platonism well, but not Aristotle's attempt to explain perishable things scientifically as well. The fact that his authorities contain contradictions was apparently not seen as a major problem by Isidore. He often just reports contradicting authorities one after the other. As Fontaine puts it (1959–1983: 2:775):[91]

> Cette pure et simple juxtaposition des sources, qui admet souvent sans discussion la contradiction entre les fragments assemblés, représente le niveau le plus élémentaire de la compilation 'doxographique', celle que les théologiens grecs contemporains d'Isidore utilisent dans leur σεῖραι [*sic*]. [...] A l'image d'un monde réduit à un assemblage d'essence particulière, l'encyclopédie isidorienne s'accommode souvent de cette simple juxtaposition d'extraits.
> 'This pure and simple juxtaposition of sources, which often admits without discussion the contradiction between the assembled fragments, represents the most elementary level of "doxographic" compilation, the one used by contemporary Greek theologians, contemporaries of Isidore in their *catenae* [...]. Like a world reduced to an assemblage of particular items, Isidore's encyclopaedia is often content with this simple juxtaposition of extracts.'

Science in the Early Middle Ages?

§8 The Middle Ages are usually considered to begin after Cassiodorus and Isidore in Latin literary studies (thus often allowing a longer time span for the Hispanic *Nachblüte*). For our topic, the great caesura, however, is within the Middle Ages: before and after the twelfth century. The time before is usually divided into the Early Middle Ages or 'Dark Ages', during the warlike time of the migrations of Germanic tribes, followed by the Carolingian *renovatio*, which in turn slowly degenerates into the *saeculum ferreum* (the tenth century), and finally develops into a new cultural flowering through the eleventh century. As CISAM (Centro italiano di studi sull'alto medioevo) held a major conference on science in this epoch in 2019, a few words will suffice here; the interested reader is referred to the rich proceedings of this conference.[92]

For the present topic, in fact, there is little difference between Late Antiquity and the Early Middle Ages: Latin science remains mostly compendium and school erudition, the main method is study based on antique authorities, and first-hand research, especially in the natural sciences, remains rare. The science of the Early

91 In contrast, harmonising contradicting authorities will become the major preoccupation of the scholastic method (see chap. 11).

92 See, among others, Roelli (2020a) in the proceedings; other contributions give examples of sciences that were seriously studied in this epoch.

Middle Ages is a topic that has for long been neglected. In the past, it was occasionally claimed that the Latin Middle Ages were altogether devoid of scientific activities before the twelfth century. Even if science is defined from a modern point of view as a growing corpus of experimentally gained knowledge, some exceptions will be found to such a sweeping statement; if, however, the present broader approach is used, it will be seen that some sciences were still widely practised, of course within a Christian theological *Denkstil* – itself a product of the neo-Platonist approach, which was considered the most scientific at the time, as discussed above (§2) and below (§13). Despite the Middle Ages’ focus on repeating what Roman Antiquity knew about the Seven Arts, it is becoming increasingly acknowledged that several preconditions for scientific thought did originate in the Middle Ages, even in the natural sciences, but first and foremost in ‘sciences’ such as historiography (e.g. consistent dating of events being worked out in the widely practised *computus*), jurisprudence (mostly from the eleventh century onward in Bologna), or biblical studies and theology (beginning in Carolingian times). With their schooling in the Liberal Arts and these new developments, the earlier Middle Ages laid the foundation for the reassimilation of the Greek scientific spirit in the twelfth century, which, of course, remains the great watershed.[93]

The ‘Dark Ages’

§9 After the fall of Western Rome and during the long period of wars in Italy and Gaul, monasticism took an ever firmer hold of Latin society.[94] Monasteries usually collected books following the example of Cassiodorus (§2). In the seventh and eighth centuries, monastic libraries grew and educated teachers moved between them in order to teach the monks and younger pupils – primarily basic matters important for monastic life, such as liturgy, reading, and writing, but also Latin grammar, historiography, calendar calculation (*computus*), and the Liberal Arts. Nonetheless, in most places truly educated authors remain few and far between. Among the Longobards, during a steady growth of monasteries in the mode of St Benedict, one may think of the historian Paul the Deacon (ca. 720–799), or in Ireland from the seventh century onward a special interest in grammar can be registered.[95] Especially in Anglo-Saxon England, monastic erudition grew in this period and produced important writers such as Aldhelm (ca. 639–709) or ‘the

93 On this development, see Fried (2001).
94 Riché (1979) is still an excellent introduction to (monastic) schools in these times; for a more recent one, see Shank (2013). The proceedings of another CISAM conference (Sestan 1972) provide a wider picture of early mediaeval schools.
95 See Cardelle de Hartmann (2019).

Venerable' Bede (672/673–735).[96] Bede wrote in a clear style and was much concerned with *perspicuitas;* his intentions are nearly always didactic. He wrote a lot, even taking into account that many writings circulated under his name in the later Middle Ages and the authenticity of some is still under debate. The PL contains works attributed to him comprising some two million words. Besides being a good historian, his studies of *computus* became fundamental for calendar calculations in the following centuries; he also wrote on geography and natural philosophy. For his *Historia ecclesiastica gentis Anglorum*, he consulted much archival material in England and even had copies brought to him by a collaborator from Rome. 'His histories [...] mark momentous advances in the science of historiography' (Brown 1987: 81). On the other hand, Bede cannot be said to have been much of a natural scientist, with the possible exception of his *De temporum ratione*.[97] Indeed, his entire programme of studies was very much based on the Bible and its interpretation, and – in contrast to the young Augustine and Cassiodorus – he emphasises often that non-Christian studies are best avoided. Symptomatically, in his *Commentarii in Pentateuchum* III.22, PL 91.355D, commenting on Leviticus 22:25, he states:

> *Sed neque panis alienigenae offertur Deo, id est doctrina haereticorum, vel vana studia saecularium litterarum, quae ab Ecclesia aliena sunt. Tales hostiae repudiantur a Domino.*[98]
> 'But the bread of the woman born in foreign lands shall not be offered to God; this means teachings of the heretics, or vain studies of secular letters, which are foreign to the Church. Such offerings will be rejected by the Lord.'

Nonetheless, in good Roman and Augustinian tradition, what is useful among the sciences is appropriated. His *De natura rerum* is a reworking of Isidore and Pliny, and is 'certainly a great improvement over Isidore's *De natura*' (Brown 1987: 36), but it is still a résumé of past insights, albeit one of only a few, and of a quality rare before Carolingian times. Bede's successor Egbert taught the young Alcuin, who was to become a central figure in the Carolingian renewal.

96 Brown (1987) provides a good introduction to Bede and his writings.
97 Nothaft (2012) on *computus* in general. As Riché puts it: 'De même, l'intérêt que les Insulaires ont pour les recherches scientifiques est dicté par des préoccupations religieuses' ('Nonetheless, the interest of the islanders in scientific research is dictated by religious concerns'). But '[a]utour de la *ratio temporum*, les Insulaires reconstituent un programme scientifique qui n'existait plus dans l'école antique' ('around the *ratio temporum*, the islanders reconstitute a scientific programme that had no longer existed in the schools of Antiquity'; 1979: 60)
98 Similarly in e.g. *Allegorica expositio in Samuelem* IV.10, PL 91.711A.

§10 Charlemagne's (742–814) intention was to return to the former Roman glory with himself as the emperor.[99] After conquering the Longobardic kingdom in 774, he brought Italian scholars – Paulinus of Aquileia, Petrus of Pisa – to teach at his court. Among many other things, his ambitious *renovatio* was to entail educational reforms detailed in the *Epistola de litteris colendis* (ca. 785), probably written by Alcuin of York (ca. 735–804) after a meeting of the two in Rome, and in the much more successful *Admonitio generalis* (789).[100] The former states what a priest should know, including the topics (ed. Boretius & Krause, p. 121):

> 1. De lectionibus. 2. De cantu. 3. De scribis. 4. De notariis. 5. De diversis disciplinis. 6. De compoto. 7. De medicinali arte.
> '(i) Reading, (ii) Church singing, (iii) Scribes, (iv) Clerks, (v) The various sciences, (vi) *Computus*, (vii) The medical art.'

In his *Epistola generalis*, Charlemagne states (ed. Boretius & Krause, p. 80):

> *Igitur quia curae nobis est, ut nostrarum ecclesiarum ad meliora semper proficiat status, oblitteratam pene maiorum nostrorum desidia reparare vigilanti studio litterarum satagimus officinam, et ad pernoscenda studia liberalium artium nostro etiam quos possumus invitamus exemplo. Inter quae iam pridem universos veteris ac novi instrumenti libros, librariorum imperitia depravatos, Deo nos in omnibus adiuvante, examussim correximus.*
> 'Thus, as our care is that the condition of our churches should always progress toward improvement, we strive to repair through alert zeal the work of learning nearly obliterated by our forefathers' idleness, and we invite those we can, also by our own example, to study in depth the Liberal Arts. Among these, with God's help in everything, we have already acutely corrected all books of the Old and the New Testament that had been corrupted by the copyists' lack of erudition.'

The main goal in the Carolingian renewal movement can be seen as a gathering of available knowledge, its pedagogic reworking and standardisation, and greater *perspicuitas:*[101] the new Carolingian minuscule writing, the standardised Bible text, the standardised monastic rule (of St Benedict) all contributed to this end. The Carolingian renewal focused very much on Latin Antiquity, which may explain why it was not much of a scientific renewal, especially not where the natural sciences are concerned. But Charlemagne and his organisers produced the right kind of environment for further study: schools, libraries, a unified script, a standardised classical language. Leonhardt (2013: 123) sees here the beginning of a thousand years in which Latin was the 'indispensable language of culture and

99 More detail about his 'Renaissance' in Brown (1994). On Charlemagne see Becher (2004).
100 See Leonhardt (2013: 122) and in general Brunhölzl (1965).
101 On these aspects, see Schieffer (2010).

science' in Europe, ending symbolically with the abdication of the last Holy Roman Emperor, Francis II, in 1806.

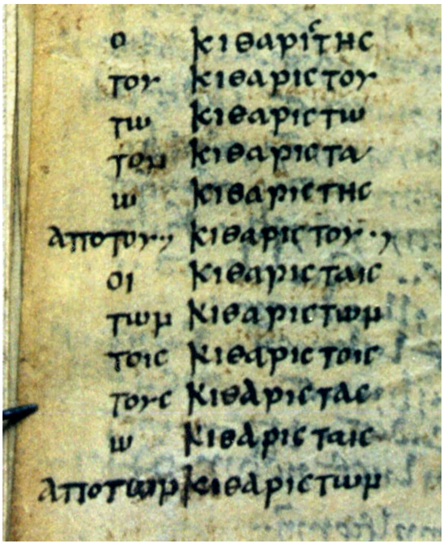

Fig. 15: *Reichenauer Schulheft*, detail showing Greek declension. Ms. Stift St. Paul im Lavanttal 86a/1, fol. 8v, detail.
Source: http://hildegard.tristram.de/schulheft.

Many of the promoters of these schools were Irish or Anglo-Saxon monks who came to the imperial court or to Frankish monasteries.[102] Indeed, the Irish seemed to feel especially attracted to difficult studies, even including some input from Greek.[103] The so-called *Reichenauer Schulheft* is a short, early ninth-century manuscript containing information on various fields, for instance grammar, Greek declension (see fig. 15),[104] astronomical tables, and the famous Old Irish poem *Pangur bán,* about a white cat. Charlemagne's ideas of empire favoured the interchange of scholars in many ways. Although there was no centralised institution of

102 'Ils apportent des manuscrits, font connaître des auteurs oubliés tel Martianus Capella, redonnent vie à l'étude des sciences et de la dialectique et enfin sont les artisans du renouveau de l'hellénisme' ('They brought manuscripts, made forgotten authors such as Martianus Capella known, revived the study of science and dialectics, and were the architects of the revival of Hellenism'; Riché 1979: 92).
103 See Berschin (1980).
104 Interestingly, an extra row for the ablative case, which does not exist in Greek, is included, with the preposition ἀπό.

learning, there definitely was a circle of intellectuals in contact with one another and with the emperor, but these scholars often moved about and were mostly in contact by letters only.[105] This web included many of the most important intellectuals of the time, such as the Franks Einhard and Angilbert, the Italian Paulinus of Aquileia, the Visigoth Theodulf, the Anglo-Saxon Alcuin, or the Irish Dungal. But the sciences were seen only as tools for a restructuring of religious life.[106] Carolingian savants of this first generation improved and unified the Latin Bible text, especially Alcuin and Theodulf of Orléans (ca. 760–821). In the next generation, Rabanus Maurus (780–856) tries to replace Isidore's *Etymologiae* with his own reorganised and moralised *De universo*. Among his numerous works, there are also many Bible commentaries. His pupil Lupus of Ferrières (ca. 805–ca. 862) was an avid finder of classical manuscripts and can be seen as an early philologist. He is often quoted for saying (*Epistola* I.5 to Einhard, ed. Marshall, p. 2):

> *Mihi satis apparet propter se ipsam appetenda sapientia.*
> 'It seems to me that wisdom is to be sought for its own sake.'

As Beeson (1930) first pointed out, in his letters Lupus often requests manuscripts of texts he already possesses in order to correct and improve their text. In the same letter to Einhard, he says (I.7, p. 3):

> *Tullii de rhetorica liber (quem quidem habeo, sed in plerisque mendosum [...]).*
> 'Cicero's book on rhetoric [*De oratore*], which I possess but is in many passages corrupt [...].'

Several dozen manuscripts survive that contain the hand of Lupus as scribe, commentator, corrector. Michael I. Allen is currently working on a new commented edition of Lupus' letters that will shed more light on his well-developed philological method.[107] In Charlemagne's entourage, a new large and alphabetical dictionary of Latin expressions, the *Liber glossarum* (ed. Grondeux & Cinato), was much used. Its content goes back to Visigothic Spain. Nonetheless, Isidore's *Etymologiae* continue to be widely used.

The renewal survived Charlemagne, who died in 814. A group of scholars remained assembled around the imperial court of his successors, especially Charles

105 See Bullough (2004) and Veyrard-Cosme (2013) for Alcuin as a letter writer.

106 '[L]a production littéraire du viii^{e} siècle est surtout religieuse: ouvrages liturgiques, commentaires exégétiques, droit canon, Vies de saints. Le comput et l'astronomie ne sont que des sciences auxiliaires à l'étude religieuse' ('The literary production of the eighth century is mainly religious: liturgical works, exegetical commentaries, canon law, lives of saints. *Computus* and astronomy were but auxiliary sciences to religious study'; Riché 1979: 111).

107 To be published in Corpus Christianorum by Brepols.

the Bald. In this milieu, Martianus Capella and with him the Liberal Arts begin to be highly appreciated again. Walahfrid Strabo (808–849) and Florus of Lyon (ca. 810–ca. 860) are important scholars in this time, but the most outstanding one was certainly John Scotus Eriugena (810–877), who learned and translated Greek and will be treated in more detail below. Many schools in what is now northern France fostered a culture of the book and of learning across generations of masters and pupils. These schools also exchanged manuscripts and staff.[108] A generation later, Remigius of Auxerre (ca. 841–908) wrote his very lucid commentary on Martianus Capella, which further established the latter's work as the basis of *artes* education in the centuries to follow. The Carolingian recension of Martianus' text, which improved many corrupt passages, has to be situated in his entourage.[109] Remigius was not only interested in textual criticism but also wrote about content. For instance, he notes that the arithmetical terminology in Boethius sometimes differed from that of Martianus (e.g. *sesqualter* vs *superdimidius*).[110] In addition, Remigius also commented Donatus' *Artes*, Priscian's *Institutiones*, Eutyches' *Ars verbi*, Phocas' *Ars*, and Bede. Riché (1979: 247) describes his way of working thus:

> Il fait preuve de qualités de clarté dans une matière difficile. Il cite ces sources, confronte leurs interprétations, s'interroge sur les désaccords entre latin de grammairiens et latin biblique.
> 'He gives proof of the quality of clarity in a difficult matter. He quotes his sources, compares their interpretations, and questions the disagreements between the Latin of the grammarians and the Latin of the Bible.'

Imbibed in classical studies in the second generation of the renewal, a *goût* for Roman science emerged among these scholars – one based on the Seven Liberal Arts and Martianus Capella, who, as noted above, is quite a good representative of 'Roman science'. Practical uses were seldom far-off. For instance, astronomy is studied mostly for computistic reasons,[111] and in general science remains auxiliary to theology and the functioning of the Church in this epoch.[112] A closer look at the approach and language of two contrasting authors, Rabanus and Eriugena, follows.

108 The school of Laon was studied in depth by Contreni (1978); see further Contreni (1989).
109 See Guillaumin (2008: 1:204–205).
110 *Commentum in Martianum Capellam*, ed. Lutz, p. 213.
111 As Riché puts it: 'Le comput et l'astronomie ne sont que des sciences auxiliaires à l'étude religieuse' ('*Computus* and astronomy are only auxiliary sciences to religious studies'; 1979: 111).
112 For the monks' interest in learning, see Leclercq (2008).

The more conventional and more successful of the two, Rabanus Maurus (780–856),[113] wrote an encyclopaedia, *De rerum naturis*.[114] It is a compilation mostly interested in the allegorical theological significance of things; *scientia* is for this author first and foremost *scientia divina*. Rabanus used many sources, especially Isidore.[115] His *Computus* (edited in CCCM 44)[116] is also hardly independent: it is largely based on Bede. This work is written in the form of a didactic dialogue between master and pupil. Rabanus rarely speaks about science detached from theology, but he does acknowledge its existence, although he tends to shun discussions of points that are not clear. His aims are formulated by Rissel (1976: 328–329) thus:

> Er war vielmehr einmal bestrebt, aus der Fülle der überlieferten wissenschaftlichen Literatur die ihm als zeitlos bedeutend und allgemein anerkannt erscheinenden Inhalte auszuwählen; auf der anderen Seite verfolgte er das Ziel, die aus den Quellenwerken übernommenen Ergebnisse durch Textänderung und Neukombination der Inhalte den Auffassungen, Denkgewohnheiten und geistigen Bedürfnissen der Karolingerzeit anzupassen.
> 'On the one hand, he endeavoured to select from the handed-down wealth of scientific literature content that seemed to him to be timelessly important and generally accepted; on the other hand, he pursued the goal of adapting the results taken from his source works to the views, thinking habits, and intellectual needs of the Carolingian period by changing the texts and recombining the content.'

In his *Institutio clericorum*, he tells the reader much about his approach to the sciences, which he believed to be important for future priests. His approach is similar to and inspired by Augustine's *Doctrina christiana*. Books I–II treat ecclesiastical matters, while book III discusses knowledge in general, for instance the Seven Liberal Arts (III.18–25). Zimpel's edition shows nicely how much of the work is made up of quotations. An excerpt that is not a quotation will suffice to illustrate Rabanus' language and approach (*Institutio clericorum* III.2, ed. Zimpel, vol. 2, pp. 438–439):

> *Fundamentum autem, status et perfectio prudentiae, scientia est sanctarum scripturarum [...]. Nec enim illa, quae in libris prudentium huius saeculi vera et sapientia reperiuntur, alii quam veritati et sapientiae attribuenda sunt, quia non ab illis haec primum statuta sunt, in quorum dictis haec leguntur, sed ab aeterno manentia magis investigata sunt, quantum ipsa doctrix et inluminatrix omnium veritas et sapientia eis investigare posse concessit.*
> 'The foundation, the characteristic, and the perfection of prudence is the knowledge of Holy Scripture [...]. Nor are those things that are found to be true and wise in the books of the wise of this world to be attributed to something other than truth and wisdom, for they were not

113 On his very successful rôle as a teacher, see Felten & Nichtweiss (2006).
114 Called *De universo* in PL 111. Unfortunately, there is no critical edition of this work.
115 Heyse (1969) studied the sources.
116 See Rissel (1976).

> first asserted by those in whose books we read them but were rather discovered as eternally self-same to the extent that truth and wisdom – that teacher and illuminator of all things – allowed them to be discovered.’

As can be seen, his Latin is correct and he uses clear syntax, but he has no concerns about using rare but easily understandable words (such as *doctrix, inluminatrix*).[117] Thus, this language seems well suited for his didactic purposes. Rabanus was most of all an important Carolingian teacher.

§11 In contrast, John Scotus Eriugena (810–877) was certainly the most original thinker during the Carolingian epoch, although his direct impact on his environment was at best limited. He was an Irishman who knew and translated Greek. More of a mystic theologian and conveyor of Greek patristic ideas (which were much more heavily imbibed with neo-Platonism than their Latin counterparts) and not so much a scientist, he nevertheless discusses scientific topics in some detail. Besides several translations of Greek works, his main work, the *Periphyseon* (i.e. περὶ φύσεων), strives to integrate what he learned from the Greek Fathers into a comprehensive mystic worldview, heavily indebted to Ps-Dionysius and Maximus Confessor. The work’s form is that of a didactic dialogue between master and pupil; there are several surviving manuscripts from the entourage of its author (fig. 16).

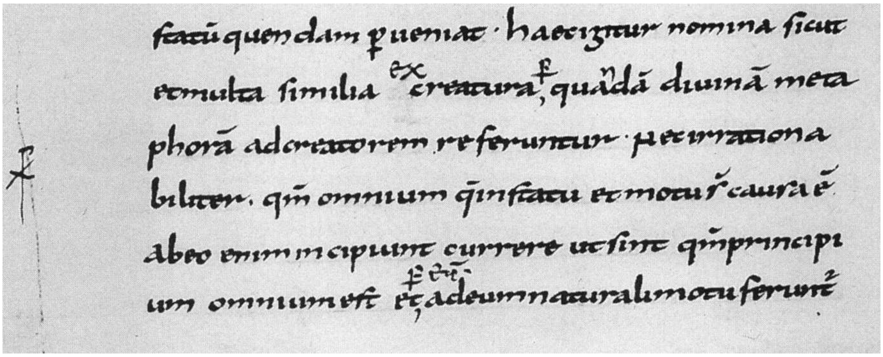

Fig. 16: Reims, Bibliothèque municipale 875, fol. 75v, showing *Periphyseon* I.12, PL 452A; one of its hands is probably Eriugena.
Source: https://commons.wikimedia.org/wiki/File:Eriugena,_Periphyseon,_Reims,_875.jpg (image by user Πυλαιμένης, public domain).

117 But both are also known from Late Antiquity according to *TLL* (s.vv.).

Both Eriugena's thought and his language give a foretaste of something between thirteenth-century scholasticism and Renaissance Platonist science.[118] Typically for the former, the *alumnus* in Eriugena's dialogue occasionally demands a *dialectica formula* of an argument to be given (e.g. PL 491C = ed. Sheldon-Williams, vol. 1, p. 146);[119] this is done in the form of a scholastic *quaestio*, *utrum*, followed by syllogisms (*collectiones*). In order to understand a topic, Aristotelian categories are invoked: *quid sit, unde sit, ubi sit […]* (PL 449A = ed. Sheldon-Williams, vol. 1, p. 52; *de theophania*), or the definition of something is sought: *quid […] id est utrum sit, quid sit vel qualis sit et quomodo diffinitur* (PL 455B = Sheldon-Williams, vol. 1, p. 66). Sometimes, Eriugena tries to harmonise seemingly conflicting views in authorities, as for instance (PL 446B = ed. Sheldon-Williams, vol. 1, p. 46):[120]

> *ac per hoc necessarium est nos rectam mediamque viam tenere ne vel Apostolo videamur resistere vel sententiam summae ac sanctae autoritatis magistri non obtineri. Utrumque igitur verum dixisse non dubitandum, immo firmiter tenendum.*
> 'and therefore it is necessary that we remain on the correct middle way, in order that we neither seem to oppose the Apostle Paul nor that we will seem not to uphold the judgement of the holy authority of the master [Augustine]. It is not to be doubted that both speak the truth, nay, this is even to be firmly held.'

Nonetheless, he judges *ratio* to be of higher *dignitas* than *auctoritas* (PL 513B–C = ed. Sheldon-Williams, vol. 1, pp. 196–198), so *auctoritas* is only used sparingly and for those who do not trust *ratio* alone (PL 781C = ed. Sheldon-Williams, vol. 4, p. 96). Indeed, *ratio* has a very central position in Eriugena's thought: it is itself the *genus* of the two *species* wisdom and science.[121] For Eriugena the difference between *sapientia* and *scientia* lies in the object and the method: while *sapientia* makes man approach the divine sphere and God through real *intelligere*, *scientia* understands the things below man in the cosmic order, that is, especially nature;

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118 On these see respectively chaps 11 and 12 below.
119 We quote the PL column and the page in the Sheldon-Williams edition, for vol. 5 that of Jeauneau. For the other volumes, passages in the Jeauneau edition can be easily located with this information. The commented reprint of Jeauneau's main text by Peter Dronke is also helpful.
120 Similarly: *Vera enim auctoritas rectae rationi non obsistit neque recta ratio verae auctoritati* ('For true authority does not oppose correct reasoning, nor correct reasoning true authority'; PL 511B = ed. Sheldon-Williams, vol. 1, p. 192).
121 *Rationis item duplex species arridet, una sapientia, altera scientia* ('Likewise, two species of reason are pleasing: one wisdom, the other science'; PL 629A = ed. Sheldon-Williams, vol. 3, p. 48).

its method is mere *rationcinari*.[122] His distinction between *sapientia* and *scientia*, and their consequent equation with *theologia* and *physica* respectively, becomes clear in PL 629A–B (= ed. Sheldon-Williams, vol. 3, pp. 48–50):

> *Sapientia namque proprie dicitur virtus illa, qua contemplativus animus, sive humanus, sive angelicus, divina, aeterna et incommutabilia considerat; sive circa primam omnium causam versetur, sive circa primordiales rerum causas, quas Pater in Verbo suo semel simulque condidit, quae species rationis a sapientibus theologia vocitatur.*
> *Scientia vero est virtus, qua theoreticus animus, sive humanus, sive angelicus, de natura rerum, ex primordialibus causis procedentium per generationem, inque genera ac species divisarum, per differentias, et proprietates tractat, sive accidentibus succumbat, sive eis careat, sive corporibus adjuncta, sive penitus ab eis libera, sive locis et temporibus distributa, sive ultra loca et tempora sui simplicitate unita atque inseparabilis. Quae species rationis Physica dicitur.*
> 'That faculty is properly called wisdom by which the contemplative mind (be it human or angelic) considers divine, eternal, and unchangeable things; whether it occupy itself with the first cause of everything, or with the first causes of things, which the Father created through his Son once and together. This kind of reasoning is called theology by the wise.
> But science is the faculty by which the contemplative mind (be it human or angelic) treats about the nature of things that proceed from the primordial causes through generation into different *genera* and *species* (through *differentiae*), and into properties; whether this faculty yield to accidents, or lacks them, whether joined with bodies, or completely free from them, whether distributed over space and time, or beyond space and time, one by its simplicity and inseparable. This kind of reasoning is called physics.'

Thus, *scientia* studies everything except God and the *causae primordiales*, which as a kind of first emanation from the fully transcendent God are responsible for the creation of everything. During the return (*reditus*) of everything to God – a theologically controversial topic – *scientia* and *sapientia* will be reached one after the other before the final union with God.[123] Eriugena divides *sophia* into πρακτική/*activa*, φυσική/*naturalis*, θεολογία/*quae de Deo disputat*, and λογική/*rationalis*,[124] but in another work he divides philosophy into διαιρετική/*divisoria*, ὁριστική/*definitiva*, ἀποδεικτική/*demonstrativa*, ἀναλυτική/*resolutiva*,[125] thus deductive, definitory, demonstrative, and analysing philosophy. While the first division is based on the topics treated (practical life, nature including *narratio istorica*

122 Schneider (1921: 67–68). It is interesting to note that modern mystics like Aldous Huxley (cf. 1955) also make such a distinction between more than rational deep 'understanding' (= *sapientia*) and mere rational/scientific 'knowledge' (= *scientia*).
123 *Periphyseon* PL 1020D, V.39, ed. Jeauneau, vol. 5, p. 225: *transitus animi in scientiam omnium, quae post Deum sunt* ('the transition of the soul to knowledge/science of everything that is after God').
124 *Periphyseon* PL 705B = ed. Sheldon-Williams, vol. 3, p. 222.
125 *De praedestinatione* PL 122.358A.

(PL 705C = ed. Sheldon-Williams, vol. 3, p. 222), divine things, with the fourth type studying the methodology of the others,[126] the second division is made exclusively according to the methods used. No source for either division is known to me; Eriugena seems, as often, to go his own way.[127] He is much less concerned with worldly *scientia* than with theological *sapientia*, as can be gleaned from his treatment of 'physical' questions in *Periphyseon* III (in an excursus from PL 715D–726A = ed. Sheldon-Williams, vol. 3, pp. 244–270, about the size of the universe): he calculates using a value for π of 2 (PL 720A = ed. Sheldon-Williams, vol. 3, p. 254), and in general he is content with referring to the opinions of others,[128] though the importance of definition is clearly seen and often used (e.g. PL 651A = ed. Sheldon-Williams, vol. 3, p. 100; a definition of *arithmetica*).

As might be expected, his language is strongly influenced by Greek.[129] The large number of Greek words that are explained and then used in his main work, the *Periphyseon*, shows that the rich neo-Platonist language had not yet been assimilated to Latin. The usual suspects – Greek words that are notoriously difficult to translate, such as ἐνέργεια, ὄν, and οὐσία – are very commonly used. In general, there seem to be three groups of other Greek words: some are used in *etymologiae*[130] Eriugena probably takes from the Greek Fathers (e.g. ἀνωτροπία to explain ἀνθρωπ(ε)ία; PL 941D, V.31, ed. Jeauneau, vol. 5, p. 114); there are a few compounds that are hard to translate, thus 'terminological Greek';[131] and there is an

126 *Periphyseon* PL 705B = ed. Sheldon-Williams, vol. 3, p. 222: *ostendit quibus regulis de unaquaque trium aliarum sophiae partibus disputandum* ('it shows by which rules of each of the other three parts of wisdom one has to discuss'). See Sheldon-Williams's commentary, p. 319.
127 Dronke, edition, *ad loc.* (vol. 3, p. 391) considers Origen (*In Canticum canticorum*, ed. Baehrens, p. 75) for the former: *Generales disciplinae quibus ad rerum scientiam pervenitur, tres sunt, quas Graeci ethicam, physicam, enopticen* [i.e. *epopticen*] *appellarunt; has nos dicere possumus moralem, naturalem, inspectivam. Nonnulli sane apud Graecos etiam logicen, quam nos rationalem possumus dicere, quarto in numero posuerunt* ('The general disciplines with the help of which one reaches knowledge [*scientia*] of things are three, the Greeks called them ethics, physics, and epoptics [theology]; we can call them [in Latin] moral, natural, and inspective [science]. Some of the Greeks, indeed, add logic, which we can call rational [science], as a fourth in number').
128 Eriugena is sometimes credited with a (nearly) heliocentric worldview, in which Mercury, Venus, Mars, and Jupiter (but not Saturn) revolve directly around the Sun (cf. PL 698A = ed. Sheldon-Williams, vol. 3, p. 206). But the fact that the topic is discussed in a mere clause, and that Saturn is not included, makes it seem that this was not a topic of great importance to him, and the system was forgotten until Tycho Brahe invented a similar one.
129 His innovative philosophical vocabulary is studied by Jeauneau (2000).
130 See chap. 21 §7 below.
131 Such as αὐτοπάθεια, ἑτερούσιον, μικρόκοσμος, ὁμοάγαθον, ὁμοούσιον, πρωτότυπος, ὑπεράγαθος, and others in ὑπερ-. Instances can be found in Corpus Corporum. The predilection for ὑπερ- is typical of mystics; cf. Plotinus, as mentioned in chap. 7 §7 above.

amazingly large group of Greek words for which there have been Latin equivalents at least since the time of Boethius but which Eriugena seems to retain in order to give the text a Greek 'flavour': Eriugena is a typical user of ornamental Greek.[132] Besides, he uses many naturalised Greek words such as *dogmatizare*. John also follows in the Areopagite's footsteps concerning language: he creates words such as *superessentialis*, or marks new differentiations with suffixes. The later scholastic trend of nominalising concepts with suffixes can be observed quite often: *numerositas* as 'number-ness', *superessentialitas et supernaturalitas*, *incircunfinite* for ἀπεριορίστως,[133] or *ipse vere ante-ὤν* and *super-ὤν* (both from Eriugena's translation of Dionysios, *De divinis nominibus*). Such words, however, reflect more the mystic who tries hard to say the inexpressible than a scientist who sets out to name newly discovered things.

With Eriugena, it could have seemed that Greek thought would enter Western Europe again, but his major work, containing a complete philosophico-theological worldview,[134] was not received very favourably. The time was not yet ripe for the re-uptake of Greek science in Latin Western Europe. The work gained a reputation of obscurity: although Eriugena did influence some other Carolingian scholars, especially Heiric and Remigius of Auxerre,[135] neither his neo-Platonist worldview nor his habit of reading Greek sources and incorporating their thought established themselves in Carolingian times – maybe due to the lack of bilingual scholars other than himself. His major work was occasionally used by writers interested in *physica*, especially in the twelfth century, for instance by Honorius Augustodunensis (in his *Clavis physicae*)[136] and possibly some of the authors of the Circle of Chartres (see chap. 10 below), but when followers of the heretic Amalricus of Bena (d. 1204) used it to support their pantheism, the work was condemned by Pope Honorius III in 1225 with vile words: as being *totus scatens vermibus heretice pravitatis* ('all swarming with worms of heretical depravity').[137] The work was largely forgotten (with the notable exception of Nicolas of Cusa and possibly Raimundus Lullus)[138] until its *editio princeps* in 1684 by Thomas Gale, after which it duly found its way into the *index librorum prohibitorum*, despite the fact that its

132 Among them are ἀνακεφαλαίωσις, ἀποφατική, ἀτμίς, διαλεκτική, διάνοια, δυάς, ἕξις, ἑρμηνεία, καταφατική, κῆτος, μεταφορά, μέτρον, στοιχεῖα, φύσις.

133 Translating Dionysius, *De divinis nominibus* I.7, ed. Suchla, p. 120.

134 The first such work in Latin, according to Riché (1979: 116).

135 See O'Meara (1988: 205–212). See also Dräseke (1908).

136 See O'Meara (1988: 216–219).

137 *Regesta pontificum romanorum*, ed. Potthast, vol. 1, p. 634.

138 See Yates (1960).

philosophical position is very close to that of Ps-Dionysius.[139] The Heiric of Auxerre just mentioned was a pupil of Lupus: the Carolingian intellectuals formed a web of scholars who knew of one another's activities and shared ideas, manuscripts, and pupils among their Carolingian schools in a way unseen since Roman times.

§12 In the later ninth and in the tenth century, in the so-called *saeculum ferreum*,[140] the Carolingian renewal slowly lost impetus, although many monastic schools and centres continued to operate. Saracen, Viking, and Magyar incursions devastated many monasteries. The tenth century is also noted for its immoral popes and their mistresses (the 'pornocracy'). Only since 1990 has the literature of this period received a justified, more positive treatment, thanks to a congress organised by Walter Berschin.[141] In this time, the education of laymen moved from monastic schools to cathedral schools, which would remain important centres of learning for several centuries. Among them were Barcelona, Vich, Reims, Cologne, Trier, and Liège. The monastery of Cluny was also founded in this time (in AD 910), 'in einer fast herrschaftslosen Region und zudem an einem kaum zu steigernden Zeitpunkt der Zersetzung klösterlichen Lebens' ('in a region almost devoid of government authority and, moreover, at a time when monastic life decomposed in a way that could hardly be increased'; Melville 2012: 56). Here began a monastic reform movement that was to grow all over Latin Europe in the subsequent two centuries. The main reasons for its success were independence from the local land-owners (Cluny was directly subordinate to the Pope), the free election of its abbot by the monks,[142] and the fact that Cluny's daughter foundations were founded as priories dependent on Cluny. This produced a Cluniac network all over Latin Europe in which books and ideas could and did move quickly. But, of course, science was not among the core interests of the Cluniacs, who were first and foremost a liturgical movement. The second abbot, Odo, was a pupil of Remigius of Auxerre, again showing the interconnectedness of the Carolingian intellectuals.

The man most interested in theoretical knowledge in these times was certainly Gerbert of Aurillac (ca. 945–1003).[143] He encountered Arabic sources in the Catalan monastery of Ripoll, where he stayed three years. Ripoll was at that

139 Ps-Dionysius was protected from being made a heretic by his fictitious apostolic authority.

140 Also *saeculum obscurum;* these names go back to Baronius (1538–1607), who used them to designate the crisis of the papacy in these times.

141 Proceedings published in Berschin (1989/1990).

142 Usually, abbots were chosen by the local lay nobility.

143 See Riché (1987); Stoppacci (2016).

time in close contact with al-Andalus, which saw a second heyday of science, learning, philosophy, and literature under Caliph ʿAbd al-Raḥman III (891–961).[144] Later in life, Gerbert taught in Reims, wrote works about mathematics, and edited Boethius' scientific works. His main interests lay in the *quadrivium:* he built astrolabes and *abaci* and wrote about them.[145] These studies do seem to have met with some interest; we know, for instance, of a case of a *magister* who exchanged a Statius manuscript for one of Gerbert's scientific instruments.[146] Remarkably, his interests were of a theoretical – scientific – not a practical type. His style betrays the influence of Cicero's orations and those of the late antique orator Aurelius Symmachus, texts that were hard to find in Gerbert's time. For the last four years of his life, he held office as Pope Silvester II. For his unusual erudition and rapid social ascent, he acquired a reputation of being a magician about half a century after his death; he did not find many followers until things changed in the twelfth century. Nonetheless, at least some disciples of Gerbert are known, such as the historian Richer and a Constantinus of Micy, and Gerbert can now be situated within his time quite well:[147] he was not as much a lone figure too early for his time, as he was sometimes seen in the past. For instance, his contemporary Abbo of Fleury (ca. 945–1004) also studied logic, *computus*, and the *quadrivium*.[148]

In the late tenth and eleventh centuries, we know of at least the following schools that taught the *quadrivium*: St Gall, Reichenau, Liège, Fleury, Chartres, and Reims.[149] In particular, the use of hitherto unknown instruments – the astrolabe and abacus – made much more precise time measurement possible.[150] Among the forerunners of the twelfth century was the 'monastic scientist' Hermann of Reichenau (1013–1054), called *Contractus* for being lame. Among other things, he wrote about the use of the astrolabe, on music theory, and a remarkable world chronicle.[151] Manitius calls him 'einer der größten Gelehrten des Mittelalters' ('one of the greatest scholars of the Middle Ages'; 1911–1931: 2:756). He appears to have had some pupils, such as Meinzo of Constance (786–787). Somewhat later, Wilhelm, abbot of Hirsau (ca. 1030–1091), made relatively precise as-

144 Samsó (1992: chap. 2). The first was under ʿAbd al-Raḥman II (792–852). Unfortunately, the library of Ripoll was destroyed in 1863.
145 On his erudition in the mathematical sciences, see Lindgren (1976).
146 Cf. *Epistolae* 134, 148, ed. Riché & Callu, pp. 328, 362.
147 Riché (1985: 68).
148 See Obrist (2004). On the use of diagrams in Fleury and Chartres, see Guerrini (2016: 33–39).
149 Riché (1979: 276). Gerbert taught the Liberal Arts in Reims.
150 See Bergmann (1985).
151 Germann (2006). See Borst (1984) for 'monastic science'.

tronomical measurements.[152] In general, the mathematical sciences started to become en vogue again in the eleventh century. Another instance is Franco of Liège (ca. 1020–1083), who attempted the quadrature of the circle. He made his task easy by assuming 22/7 to be the ratio between the circumference and diameter of the circle (i.e. π).

Similarly in medicine, some outstanding medical authors are already found in the eleventh century at the Medical School of Salerno;[153] two of them are known well enough to trace their personalities: Gariopontus (fl. in the second quarter of the eleventh century) and Constantinus Africanus (ca. 1020–1087). The latter was important as a translator (see chap. 10 §5), but the former reworked much of the then known Latin medical tradition and produced a new compendium: the *Passionarius,*[154] a very successful work (at least sixty-five manuscripts are known) despite the fact that it still lacked the new Arabic material that was soon to be translated into Latin. Compared to its early mediaeval predecessors, the Latin and the organisation of the material are much improved. Even after translations of medical works from Arabic and Greek became widespread, the *Passionarius* was still frequently copied. It was even printed several times in the fifteenth and sixteenth centuries. Its content was apparently not seen as outdated by the translations.

These examples show that in many scientific fields, important novelties already appear in the eleventh century, preparing the way for what might be called an intellectual revolution in the twelfth century; other fields would follow suit up to the middle of that century, as will be shown in the next chapter. The twelfth-century 'scientific revolution'[155] was equally slow, but also at least equally profound, as that in the sixteenth and seventeenth centuries.

Relation to criteria for science

§13 From this sketch of scientific activity in Christian Late Antiquity and the Early Middle Ages (before the long twelfth century) in Latin, one gets the impression that it does not compare so badly with similar activities during the epoch treated in the previous chapter. Indeed, for technology it has now become established fact how far the times of the Carolingian renewal surpassed the Romans in many fields: they made important advances in agriculture, heating, and other fields, in-

152 See Wiesenbach (1991: 125–128).

153 On the school, see Jacquart & Paravicini Bagliani (2007); Kristeller (1986).

154 On which see Glaze (2009). She intends to edit the text. The Lugduni, 1526 edition can be read online at https://www.e-rara.ch/zuz/content/titleinfo/9400142.

155 On the validity of such a term, see chap. 13 §§1–3.

cluding the invention of completely new devices and materials such as borax and salmiak as flux in soldering (ca. 800). Technological advances continue in the later Middle Ages – e.g. mechanical clocks, ca. 1300 – making it clear that the Middle Ages were by no means an age of technological stagnation.[156] In more theoretical scientific matters, the picture may be somewhat less positive, although we must take care not to see the times before the twelfth century through the eyes of the time after it, as the *Denkstil* was different.

Latin scientific activities (in a broad sense) may be summarised as having had their central focus move away from rhetoric toward theology among Christians, but the approach to science and learning does not seem to change much between Late Antiquity and the eleventh century. The central outlook is encyclopaedic and traditional; innovation is by and large innovation by newly combining known 'facts', creative imitation, and recomposition.[157] This is why Late Antiquity has been called the age of résumés (§1 above). Another trait of both parts of this epoch is that the Seven Liberal Arts are often used as the classification scheme for science and learning. This scheme dates from Late Antiquity: there was no standard division of science and learning in Hellenistic and early imperial times. The next chapter will show how new approaches gradually replaced this overly rigid and narrow scheme in the twelfth century.

Of course, the long epoch studied in this chapter does still fall quite naturally into two blocks separated by the barbarian invasions that ended the Western Roman Empire. As, however, the cultural decline was of very variable speed, rather little time passed between the last exponents of Roman education (such as Isidore, d. 636) and the first signs of the Carolingian renewal (such as Bede, b. 672) – reducing the core of the 'Dark Ages' to a generation or two. In Carolingian times, the renovation was not most notably a scientific one: on the one hand, Christian learning and practice was renovated, standardised, and approached in a more scholarly way; on the other hand, antique Roman culture was renewed, and with it its *Handbuchwissenschaft*. In all of this, the didactic aspects usually outweighed proper scientific curiosity, as we have seen in the example of Rabanus Maurus. Similarly, the scientific interests of Bede were subjugated to his spiritual interests. Even the apparent exception Eriugena was a mystic theologian with a very limited interest in science beyond its use as an auxiliary enterprise. Things only change with Gerbert – who should in fact rather be seen as a forerunner of the twelfth century – as well as with some scholars of the eleventh century.

156 See Hägermann & Schneider (1991: esp. 322); Lindgren (1996: 198–204 on soldering, 391–398 on mechanical clocks).

157 Cardelle de Hartmann (2015: esp. 365–366) speaks of 'kreative Imitation' in the context of the poetess Hrotsvit of Gandersheim, but the term applies well to the general culture of this time too.

The language of the authors treated here is in general much less rhetorically coloured than that of 'classical' authors such as Cicero or Seneca. A didactic approach and *perspicuitas* seem to be of greater importance to most of them. Accordingly, the rhetorical disdain for coining new words diminishes, and would continue to do so until Renaissance classicists wanted to turn the clock back to Ciceronian times. Among early Latin Christians, Tertullian, Augustine, and Jerome in particular paved the way for mediaeval Christian Latin and its greater openness to novel ways of expression compared to classical rhetorical Latin. They thus fulfilled an important rôle as language innovators; but in addition to this, the formulation of Christian dogma in the fourth and fifth centuries – the most palpable expression of the Christian *Denkstil* – can also be likened to a scientific process fulfilling surprisingly many of the above criteria (chap. 4, §5): in these discussions about the nature of God, the Trinity, Christ, and their relationship to the created world, which were often held at oecumenical councils ('international conferences'), there definitely was a community effort (V); the results were condensed into highly formalised statements such as the Creed (VI); and clear, unambiguous terminology (ii) was sought and fought for (compare e.g. the term ὁμοούσιος). There is definitely a systematic method (I) based on the study of Holy Scripture and the experience of saints and mystics. There was also a coherent system (IV), largely based on biblical studies and their auxiliaries; the topics are well defined. We have met some (mostly monastic) centres where a community of scholars worked and passed their approaches on to the next generation (V). The theological superstructure that was its product and is still the doctrinal basis of all Christian groups accepting Chalcedon (AD 451) today, was a coherent and fruitful way (IV) of thinking about God and the world. As the enormous amount of Christian theological literature intimates, it led to a Christian *Denkstil* that characterised the mediaeval world in which modern science as a society-wide phenomenon originated. Of course, from today's point of view, we may perceive a lack of testability and step-by-step explanations (II), and a rather arbitrary choice of accepted Scripture as its bases, besides the not-impartial (III) influence of politics at many of the councils,[158] as reasons not to consider the formation of Christian dogma as a scientific process. But testability has only recently become of fundamental importance, and many other sciences in Antiquity were quite lacking in it as

158 A good example is the Council of Ephesus (AD 431) and Cyril of Alexandria's machinations. But the influence of politics can still be a hindrance to scientific understanding today. There were conspicuous examples in the Soviet Union where Marxist principles were not allowed to be contradicted (e.g. Lysenko vs Darwinian evolution), and even today certain creed topics cannot be studied scientifically (e.g. a possible link between human groups and mental traits) because they do not fit into the current political agenda.

well.[159] Below, we shall see that theology becomes the paradigmatic science in scholastic times. Among the auxiliary sciences cultivated within this Christian *Denkstil*, *computus* in particular, producing an accurate world chronology, can fulfil further criteria by explaining step-by-step (II) and sometimes by being testable and impartial (III), although strictly disinterested studies reaching the rigour of Greek science are lacking. On the whole, formalisation (VI) can be seen as the weakest point in this epoch; moreover, the linking of criteria II (observation) and III (explanation) was weak: the entire epoch clearly cannot stand up to comparison with antique Greek science, but as much science as was cultivated had in nearly all cases strong Greek roots. Even the new Christian *Denkstil* largely developed in Greek, and was then taken over more fully than in other fields in the Latin world. Other 'learning' is comparable to non-Greek learning in other highly developed cultures: the key Greek interplay of open and unbiased observation and explanation is very rarely seen in Latin before the twelfth century with its return of the Greek *Denkstil*.

It is interesting to note in passing that during the time of the Carolingian renewal, Greek scientific texts were translated into Syriac and soon further translated into Arabic: something that was not yet happening in the Latin world. This enterprise was begun under Caliph Hārūn al-Rašīd around AD 800 and continued under his son al-Maʾmūn. The precise rôle of the caliph and his library, the House of Wisdom (*bayt al-ḥikma*), in this process is debated.[160] The adoption of Greek learning led to significant scientific and technological advances in the Arabic-speaking empire, which were to bear fruit over several centuries.[161] The Arabs differentiated religious sciences (*ʿulūm al-qurʾān* or *al-ʿarab,* later usually *ʿilm al-kalām*),[162] required to study, recite, and expound the Quran, from the sciences of the ancients (*ʿulūm al-awāʾil*). The 'ancients' were mostly the Greeks, although the Arabs did not eschew learning from Indians, Persians, and Latins in some cases.[163] Especially in al-Andalus, there are traces of Arabic reception of preconquest Latin studies.[164] The Syriac and Arabic translators had to solve similar linguistic problems to those facing their Latin colleagues – and indeed also more difficult ones, as their target language was not at all related to Greek and had lim-

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159 And it is still very much debated what testability is sufficient; consider the replication crisis in human and medical sciences that is currently unfolding (Ioannidis 2005; chap. 4 §8 above).

160 On the sources for the House of Wisdom, see Balty-Guesdon (1992); on other scientific institutions as well, see Micheau (1997).

161 See the introductions in Endress (1982–1992: 3:chap. 8).

162 e.g. al-Fārābī, *De scientiis* 3, ed. Palencia.

163 Finer classifications of the sciences of the ancients are studied by Jolivet (1997: 255–270).

164 Samsó (1992: 41–43). See also Vernet & Samsó (1997).

ited possibilities for coining new words (see chap. 22 below). Jacquart (1994) discusses interesting cases of neologisms in several different sciences in Arabic. The blossoming of the sciences in Arabic between the ninth and the thirteenth century shows the translators' success.[165] Much Arabic science and lore was to be translated into Latin in the twelfth century (see chap. 10 §5).

165 See Rashed (1997).

10 The adoption of the Greek Denkstil

§1 The twelfth century brought change to many facets of life in Latin Europe. Reference is often made to the 'long' twelfth century, intending it to last approximately from the last quarter of the eleventh century, sometimes 1095 (First Crusade and ensuing cultural contacts), to 1215 (Fourth Lateran Council) or even 1229 (Frederick II's peace treaty in Jerusalem).[1] Some epochal changes happened already in the second half of the eleventh century: in 1054 the schism between the Greek and the Latin Church, which was to be lasting; in 1066 the Battle of Hastings; in 1071 the Battle of Manzikert, establishing the Seljuks in Asia Minor for good.

Haskins (1933) hailed this long century as a 'renaissance', hinting that the really fundamental break in the intellectual history of Europe did not happen in the fifteenth century but in the twelfth.[2] Le Goff (1957) saw the emergence of 'intellectuals' for the first time in this period. Among the reasons for the many changes in the twelfth century are external ones such as the Mediaeval Warm Period and resulting economic improvements, but also a better acquaintance with more remote places and cultures, especially the Arabic world (*reconquista* of Toledo 1085, Crusades from 1095).[3] The Latins, especially, could profit from the preceding Arabic scientific flowering in the *ṭāifa* principalities in Spain (1031–1086).[4] The now Christian Toledo became an important centre for Latin learning.[5] The internal aspects of Latin society, however, will have been of even greater importance: with St Augustine's approach, the early mediaeval Christian *Denkstil* contained *in nuce* the idea of cultivating arts and sciences in a Hellenistic way, as was pointed out in the previous chapter.[6] And indeed, conspicuous new interests

1 Rexroth (2018: 129) sees the important intellectual changes already around 1070.

2 This had already been one of the major points of Duhem (1913–1959). The subsequent *Forschungsgeschichte* is summarised in Giraud (2020: 1–9).

3 See Boshof (2007) on the historical background and Swanson (1999: esp. chap. 5) on the changes in science and education, and now also Giraud (2020) on the crucial changes in schooling.

4 Dates from Samsó (1992: 125), who speaks of their 'siglo de oro', acknowledging that it was a somewhat short 'century'. The greater part of Samsó's book covers this key period (chaps 3–4).

5 On Toledo, with further references, see Rexroth (2018: 248–252).

6 Similarly Kluxen: '[…] dass die wissenschaftliche Rationalität als Prinzip im Kontext des christlichen Erbes als Bildungselement enthalten war, so dass ihre spontane Entfaltung, die im 12. Jahrhundert stattfand, möglich war, als legitim empfunden wurde und trotz der arabischen und griechischen Einwirkung auch als eigenes Eigentum betrachtet werden durfte' ('[…] that scientific rationality as a principle was included as an educational element in the context of the Christian heritage, so that its spontaneous unfolding, which took place in the twelfth century, was possible,

https://doi.org/10.1515/9783110745832-011

leading quite organically into the much-accelerated twelfth-century development had already appeared a century earlier with scientists such as Gerbert, Hermann, Franco, or Gariopontus and their schools. Important early transmitters and amplifiers of new ways of studying and thinking were schools, such as the medical one in Salerno (chap. 9 §12), that became innovative already around the middle of the eleventh century (before the translations), or the monasteries of Ripoll (where Gerbert studied)[7] or Monte Cassino, where historiography, hagiography, medicine, and cosmology[8] were studied in the eleventh century.[9] The translations from Greek and Arabic (§5) certainly accelerated this process, but do not lie at its root. The various geographical centres of the translation schools and of important intellectual movements already provide an indication of this. In some cases, it can still be seen how individual scholars brought important changes to entire scientific fields before the translations, for instance Guido of Arezzo, who invented a new kind of musical notation in his *Micrologus* around 1025, and who pointed out (*Regulae rhythmicae*, lines 1–3, ed. Rusconi, p. 88):

> *Musicorum et cantorum magna est distantia:*
> *Isti dicunt, illi sciunt, quae componit musica.*
> *Nam qui facit quod non sapit, diffinitur bestia.*
> 'There is a big difference between musicians [who do not use notes] and cantors [who do]; the former recite and the latter know the principles of music. But to do what one does not know is the definition of a brute.'

Thus, internal roots of the twelfth-century intellectual development can clearly be made out all through the eleventh century. They culminated in novel ways of teaching, thinking, and acting among intellectuals in the twelfth century, and sparked new approaches in many different directions, especially in what has been aptly called 'myth and science' (Stock 1972). Some of these will be presented in this chapter. They were finally to solidify into what is known as the Late Middle Ages with its scholasticism, university structure, central papal power, and so forth. As Peter von Moos put it: 'Das 12. Jh. ist kein monolithisches, sondern ein überaus buntes, chaotisches und explosives Zeitalter' ('The twelfth century is not a monolithic, but an extremely colourful, chaotic, and explosive age'; (1988a: 6). Initially, schools and scholars are still mostly active at monastic schools such as Bec or St Victor, but cathedral schools soon take over, for instance Orléans, Laon,

was perceived as legitimate, and could also be regarded as its own property despite Arab and Greek influence'; 1981: 289–290).

7 But declining after the death of Abbot Oliba in 1046.

8 See Albiero & Draelants (2018), esp. Draelants (2018).

9 Details in Riché (1979: 157); Newton (1999).

and Chartres. Highly mobile Church movements such as the Cluniacs facilitate the movement of ideas all over Latin Europe. Among the many new interests in this time was a renewed interest in antique Greek science: this century is among other things the watershed for the adoption of the Greek scientific spirit among Latin writers for the first time, prepared internally (§§1–4), then boosted by the translations (§§5–6).

§2 The Seven Liberal Arts began to be seen as insufficient to contain all scientific learning: many writers now teach *physica, historia, medicina,* or other *artes* not contained in the schema. For example, Hugh of St Victor discusses many such 'new' arts in book III of his *Didascalicon*.[10] A French poem from the early thirteenth century, *La bataille des sept arts* by Henry d'Andeli (fl. ca. 1230), illustrates this conflict very nicely in a figurative way: the new Paris dialecticians fight against the Orléans grammarians. The former are seen by the latter as 'quiqueliquique' (line 16, ed. Paetow, p. 38), a word of uncertain meaning that seems to evoke the dialecticians' frequent use of *quid, qualis*, and similar question-words. The Paris dialecticians vanquish the Orléans grammarians, very much to the spite of the author, who prophesised a comeback of the Liberal Arts within 'thirty years' (line 452, p. 60). This was not to happen: the process of overcoming the scheme of the Seven Arts can be seen as complete half a century later, when Aquinas concludes (*In Boethii De trinititate* q. 5, a. 1, ad 3, Leonina edition, vol. 50, p. 139):

> *septem artes liberales non sufficienter diuidunt philosophiam theoreticam.*
> 'the Seven Liberal Arts are not a sufficient classification of theoretical philosophy.'

The new interests are graphically illustrated by the crypt of St Magnus in Anagni near Rome (fig. 17), depicting scientists in discussion about scientific theories (from the *Timaeus*) in a church.

10 He tries to solve the problem by relegating unfitting arts to being mere *appendentia artium* (III.4, ed. Offergeld, p. 230). In good Platonist manner, he points out that this is because *in aliqua extra philosophiam materia versantur* (i.e. they deal with perishables).

Fig. 17: Crypt of St Magnus in Anagni illustrating the new interests of the twelfth century: Hippocrates and Galen are discussing science. Photograph by the author (2018).

Possibly in conjunction with this new Greek scientific spirit, there seems to be a growing awareness that a more precise language is required to understand things better. Leonardi (1983: 10) sums up about this time:

> tutti questi nuovi fermenti hanno pure un elemento in comune: quello di non poter più usare semplicemente le parole della fede, della Bibbia e dei Padri, sia pure con il supporto delle arti liberali, per comprendere Dio, l'uomo e la storia: di avere bisogno di altre parole, e di un ordine rigoroso tra di esse, per capire la realtà: la logica antica viene così ripresa, come capace di una analisi del linguaggio e dei suoi valori semantici.
> 'all these new ferments have one thing in common: that they can no longer simply use the wording of faith, the Bible, and the Fathers, albeit with the support of the Liberal Arts, to understand God, man, and history: they need different words, and a strict order between them, to understand reality: ancient logic is thus taken up again, as capable of an analysis of language and its semantic values.'

Indeed, in this century new dictionaries aiming to describe the entire Latin vocabulary and its *etymologiae* were made. The most famous ones are Osbern of Gloucester's (1123–1200) *Panormia* and Hugutio of Pisa's (d. 1210) *Liber derivationum*. They used new ways of presenting the lexicographical content, such as a strictly alphabetical order (to the second or even third letter of lemmata) and the addition of indexes. More complex and more complete such works will follow in the thirteenth century. The scholarly study of the Bible also profited from new aids. Anselm of Laon (d. 1117) and his pupils at the cathedral school of Laon gathered explanatory excerpts from the Fathers for the entire Bible, thus establishing what was soon to be called the *glossa ordinaria* and became the foundation for scientific studies of the biblical texts.[11] Figure 18 shows a sample page depicting how the commentaries are presented on the same page as the Bible text. Soon this *glossa* becomes so fundamental as a quarry of theological information that its origins are forgotten. The early modern edition reprinted in PL believed that it went back to Carolingian times.

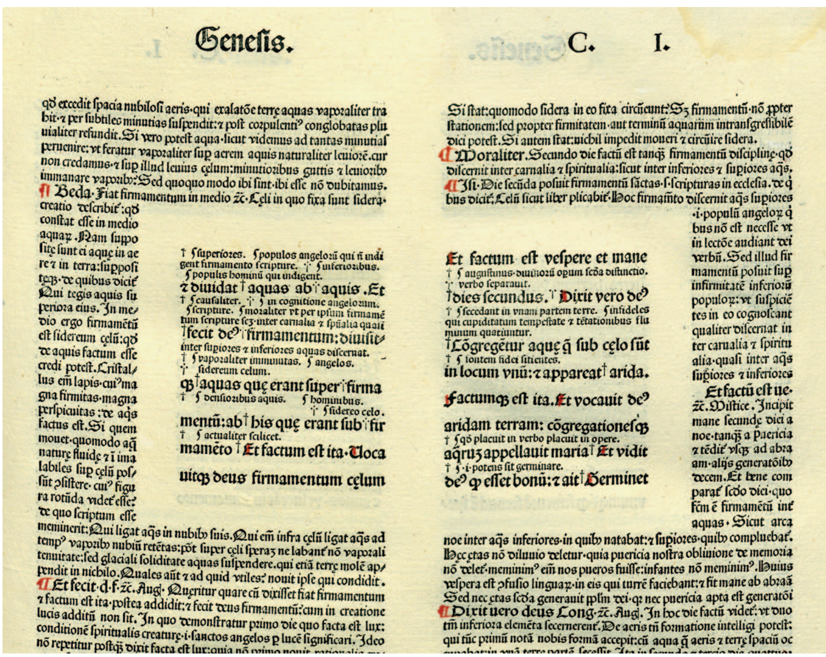
Genesis. C. I.

Fig. 18: Excerpt from the *Glossa ordinaria* for Genesis 1, [Nuremberg], before 1480, GW 4282 (BSB München, 2 Inc.s.a 213-1). The text in the centre is the biblical passage including interlinear glosses explaining words (often from Jerome); the text around it quotes relevant commentaries from the Fathers. This incunabulum reproduces the usual manuscript layout.
Source: http://daten.digitale-sammlungen.de/bsb00096042/image_15.

11 See Smith (2009). The best edition to date is a facsimile of an incunabulum (*Biblia latina cum glossa ordinaria*). An online edition project is under way at http://gloss-e.irht.cnrs.fr/php/livres-liste.php. The text printed in PL is unreliable.

Another crucial field seeing great changes in the same timeframe is jurisprudence: Irnerius (fl. ca. 1100) rediscovered the Justinian *Corpus iuris civilis* and edited it with glosses at the school of Bologna. A movement of collecting authoritative comments or glosses on legal texts can be observed soon afterwards, finding its acme in Bologna when Gratian collects the fundamental *Concordia discordantium canonum* (ca. 1150).[12] The work of these jurists was collected into a definite form in the thirteenth century by Accursius (ca. 1182–1263).[13] These and similar novelties of the twelfth century share a desire to get hold of more accurate and more easily consultable authoritative knowledge. Easier access to information certainly facilitates new ways of thinking.

The foregoing makes it clear that we cannot speak of a single *Denkstil* or approach to science in this epoch. In what follows, a few key movements and individual authors will be briefly introduced.[14] In a later chapter (chap. 20), two anonymous arithmeticians of the twelfth century will also be presented. The past few decades have seen significant advances in the study of the twelfth century, but there are still many texts and authors that have hardly been studied and works whose authorship is unclear or which are still extant only in manuscript form.

§3 Especially the new school of St Victor (close to Paris),[15] where a community of clerics established by the innovative teacher William of Champeaux lived since 1108,[16] developed biblical studies further. Their innovative methodology has been studied in depth by Linde (2012). Among its members were important ecclesiastic poets (Adam of St Victor), mystical theologians (Richard of St Victor), Old Testament exegetes (Andrew of St Victor), and perhaps most importantly the scholar Hugh of St Victor (ca. 1100–1141), who could read some Greek and Hebrew. His influential work *Didascalicon,* a work on how to read and study, has already been cited several times.[17] Its two parts treat biblical and secular studies equally, the overall goal being wisdom (I.1, ed. Offergeld, p. 110):

> *Omnium expetendorum prima est sapientia, in qua perfecti boni forma consistit.*
> 'Of all desirable things the first is wisdom; in it the form of the perfect good man consists.'

The two parts of the book are not linked at all, nor is there any obvious hierarchy in their value, but in both a clear, systematic methodology is required in order to

12 In short referred to as the *Decretum Gratiani*.
13 On important novelties in theology and jurisprudence, see Giraud (2020: chaps 10–12).
14 Some more are described in Dronke (1988).
15 On the school, see Berndt (2000).
16 On William see Rexroth (2018: 120–127).
17 See Poirel (2020), including a table of authorities he quotes for different fields (134–137).

reach *sapientia*.[18] Hugh shows an openness quite unthinkable before this epoch (VI.3, ed. Offergeld, p. 364):

> *Omnia disce, videbis postea nihil esse superfluum.*
> 'Learn everything; you will then see that nothing is superfluous.'

This reminds us of the early Augustine (*De doctrina christiana* II.18(28), ed. Green, p. 54):

> *Immo vero quisquis bonus verusque Christianus est, domini sui esse intellegat ubicumque invenerit veritatem.*
> 'Whoever is indeed a good and true Christian should understand that wherever he finds truth, it belongs to his Lord.'

Hugh is also remarkable for proposing new divisions of science. He distinguishes in his *Didascalicon* (VI, appendix A, ed. Offergeld, p. 404):[19]

> *Quatuor igitur sunt principales scientiae, a quibus omnes aliae descendunt: theorica, practica, mechanica, logica.*
> 'The main sciences are four from which all others derive: the theoretical, practical, mechanical, and logical ones.'

He thereby takes up divisions from Antiquity containing roughly (respectively) theology, physics, mathematics (i.e. the *quadrivium*); ethics, economy, law; manual arts (unusually included as *scientiae*); and the *trivium*. Hugh also wrote treatises on specific sciences, such as cartography and geography (ed. Gautier Dalché). Interestingly, he did not yet have access to the Aristotle translations[20] but still developed a very similar approach to science (including using *scientia* as the term for it) to them. New divisions of science were to become en vogue with the translation movement a few years later (see §6).

Although Anselm of Canterbury (ca. 1033–1109) was a pre-scholastic theologian and can hardly be called a scientist, his new approach was to become important for science. Originally from Aosta, Anselm was one of the famous new teachers of the end of the eleventh century. Students now travelled far to hear the best teacher, as Anselm himself had done by moving to Bec in Normandy to hear Lanfranc. Under Anselm, who became his successor, Bec grew into one of the key

18 Thilo Offergeld speaks of the 'Propagierung einer methodisch planvollen Arbeitsweise' ('propagation of a methodologically planned working method'; edition, p. 78). On Hugh's approaches to a system of *ars*, *scientia*, and *philosophia*, see Baron (1957: chap. 2).
19 A similar classification is found in the *Leipzig Ordo artium*, ed. Gompf.
20 Judging from the apparatus fontium of Buttimer's edition. Hugh quotes a lot from Augustine, Boethius, and Isidore.

intellectual centres in Latin Europe. His most conspicuous innovation may be the idea of proving God's existence by *ratio* alone, especially with his ontological proof of the existence of God (in the *Proslogion*). His highly influential sermons exhibit a new style: biblical parallelisms and repetitions, but interspersed with terse dialectics. In the *Proslogion* and *Monologion*, every chapter has the same structure. The title usually asks a question with *quod* or *quomodo*. The text proper begins with a *status quaestionis,* and then a question introduced with *an* (sometimes *numquid* or *si*) proposes a solution for the problem. This is then substantiated with arguments that are presented with *nam* (*namque, enim, quippe, nempe*). A conclusion begins with *ergo* and concludes the chapter. The similarity to the later scholastic *quaestio* is striking. Quite in general, Anselm uses two very different styles, so much so that Schmitt in his edition of the *Proslogion* prints them in different layouts. He observes (edition, p. 15):

> Wir können im Schrifttum Anselms zwei Stilarten feststellen: die eine ist die sachliche Prosa, die auf alle rhetorischen Kunstmittel zugunsten der Präzision des Gedankens verzichtet; die andere ist die rhetorische, die bewußt die stilistischen und rhetorischen Kunstmittel anwendet. Die Kunstprosa findet sich durchweg in den von ihm herausgegebenen 'Gebeten und Betrachtungen'. Außerdem in einigen Teilen des 'Proslogion'. Im Parallelismus der Satzglieder, in der Antithese und in der Anaphora besitzen wir die Mittel, beinahe haarscharf die Partien der einen Stilart von denen der anderen in dem Werke zu scheiden.
> 'We can identify two kinds of style in Anselm's writing: one is factual prose, which dispenses with all rhetorical devices in favour of the precision of thought; the other is rhetorical prose, which consciously uses stylistic and rhetorical devices. Artistic prose is found throughout in his "prayers and reflections", and also in some parts of the *Proslogion*. With the parallelism of the parts of the sentences, the antitheses, and the anaphoras, we have the means to distinguish, almost by a hair's breadth, the parts in one style from those in the other in the work.'

Around the turn of the twelfth century, a new culture of schools, of which Lanfranc and Anselm were early exponents, develops in France, with a special emphasis on disputation and dialectics. Verger speaks of a 'révolution scolaire' ('school revolution'; 2013a: 22) around the year 1100 based on a 'double mutation, institutionelle et mentale' ('double change: in institutions and mentally'; 212). The most typical and far-reaching novelty of the often mobile teachers of the late eleventh and early twelfth century may be that the *magistri* disputed with and against one another and often moved from place to place, thus competing openly.[21] Among the many teachers and dialecticians, Petrus Abaelard (1079–1142) was in many respects

21 Pointed out e.g. by Kluxen (1981: 279).

the outstanding personality.[22] He had studied with many of the most famous teachers of his time, among them Anselm of Laon and William of Champeaux. His many novel and unusual ideas (and his difficult character) brought him mostly 'calamities' (cf. his autobiography, the *Historia calamitatum*). Peter the Venerable, who sheltered him in his monastery during the last years of his life after he had fallen into conflict with the Church, wrote on his epitaph (*Carmina*, *In epitaphio Petri Abaelardi versus* PL 189.1022D):

> *Gallorum Socrates, Plato maximus Hesperiarum,*
> *noster Aristoteles, logicis quicunque fuerunt*
> *aut par aut melior; studiorum cognitus orbi*
> *princeps, ingenio varius, subtilis et acer;*
> *Omnia vi superans rationis, et arte loquendi,*
> *Abaelardus erat.*
> 'The Socrates of the French, the greatest Plato of the West, our Aristotle, to all logicians that have been he was equal or superior. Acknowledged prince to the world of studies, versatile in his capabilities, subtle and acute. Overcoming all with the power of his reason and eloquence, this was Abelard.'

Abelard indeed stressed the importance of *dialectica* and human *ratio* emphatically.[23] He teaches his son (*Carmen ad Astralabium* lines 7–8, ed. Rubingh-Bosscher, p. 107):

> *non a quo sed quod dicatur sit tibi curae: [...]*
> 'Not by whom, but what is said should be your concern: [...].'

For an understanding of his theological and philological method, the work *Sic et non* is in many respects indicative. After teaching his reader to be wary of errors in manuscripts, wrong attributions, and different degrees of authority of texts, he teaches how to collect authoritative statements on a given theological question. The *Sic et non* shows clearly that these can easily be in serious disagreement, but it does not tell the reader what to do in such cases; it just offers pros and cons from authoritative texts on some questions.[24] The solution is left to the reader. Abelard's approach is clearly the use of *ratio* in such cases, in order to advance from doubt through enquiry to the truth, as he states in the important preface (*Sic et non* praef., ed. Boyer & McKeon, pp. 103–104):

22 On him see Mews (1995). See also Werner Robl's Internet page on Abelard, especially on his method: http://www.abaelard.de/050503sicnond.htm.

23 On his philosophical approach, see Marenbon (1997).

24 e.g. *Quod nihil fiat casu, et contra* ('That nothing happens by chance, and against this'; q. 28).

> *His autem praelibatis placet, ut instituimus, diversa sanctorum patrum dicta colligere, quae nostrae occurrerint memoriae aliquam ex dissonantia quam habere videntur quaestionem contrahentia, quae teneros lectores ad maximum inquirendae veritatis exercitium provocent et acutiores ex inquisitione reddant. Haec quippe prima sapientiae clavis definitur assidua scilicet seu frequens interrogatio; ad quam quidem toto desiderio arripiendam philosophus ille omnium perspicacissimus Aristoteles in praedicamento Ad Aliquid studiosos adhortatur, dicens: 'Fortasse autem difficile est de huiusmodi rebus confidenter declarare nisi saepe pertractata sint.' Dubitare autem de singulis non erit inutile. Dubitando enim ad inquisitionem venimus; inquirendo veritatem percipimus.*
> 'After these points have been made, it seems proper, as we have set about, to collect some sayings of the Holy Fathers, as they occur to our memory, condensed from the apparent contradictions into a question [each] that ought to spurn young readers to the highest exercise of finding truth and to make them more acute through enquiry. For this is defined as the first key to wisdom: assiduous and habitual asking of questions. In order that it be seized with full desire, the most perspicacious philosopher of them all, Aristotle, admonishes students when speaking about the category πρός τι: "It may be difficult to confidently speak about such things, if they are not treated often."[25] It will not be useless to doubt about individual points. For through doubt we come to asking questions, by asking we perceive truth.'

This approach makes Abelard a forerunner of thirteenth-century scholasticism. As a logician, he was an early Aristotelian, before the new Aristotle translations became available. Abelard is important for his methodological approach (in a similar way as Francis Bacon will be), not so much for his own scientific contributions. In fact, he did not show special interest in 'nature', in contrast to the authors in the next section. Abelard is seldom quoted by later mediaeval writers (certainly also because of his difficult character and the many enemies he made in life), but the influence of his philological and rational approach to theology and to the intellectual climate was nonetheless great and lasting.

In general, this dialectic renaissance of disputing *magistri* and their pupils[26] in the early twelfth century may indeed be comparable to the Attic sophists (including Socrates, to whom Peter the Venerable compared Abelard, not without reason): their new focus on language and eristics was not in itself of a scientific nature, but they produced better linguistic tools that could be used to advance in science. The first fruits of this development can be seen in the next movement to be discussed; in the long run, this would grow into the thirteenth-century universities (discussed in the next chapter).

25 Cf. *Categoriae* 7.23, 8b21–24.

26 Well depicted in Rexroth (2018: chaps 5–6), especially in connection with Abelard. On the pupil–teacher relationship that began in the late eleventh century, see Leyser (1984).

§4 The most important intellectual circle to produce and assimilate new ideas was certainly the one centred on Chartres. Its origins lie more in Augustine and the Seven Liberal Arts, thus before the translation movement (§5). It does not seem to have been very organised (not enough to warrant being called a 'school'),[27] although its origins were located at the cathedral school of Chartres, which had already been founded in the early eleventh century by Fulbert of Chartres (d. 1028), another pupil of Gerbert. Thierry of Chartres can be seen as the circle's initiator (d. ca. 1150); he wrote a manual on the Seven Arts and proposed equating the Holy Spirit with the Platonic *anima mundi*. Typical for the members of this circle is intense study of the then accessible Platonic texts, skewed by transmission toward natural philosophy (*Timaeus*). Before they could get access to the new translations, Chartres Platonists mainly drew on the few Platonist Latin sources mentioned above (chap. 9 §3). Besides these, the Platonic mystical theology of Ps-Dionysius was available in two translations, and Augustine often alludes to Platonic teaching. Two more Plato dialogues were translated around the middle of the twelfth century by Henricus Aristippus (*Meno* and *Phaedo*), although without much success. Thus, the circle's main interest became Nature (*Natura*), the *macrocosmus,* as a largely independent creation of God, on the one hand, Man as the *microcosmus* in contrast to it on the other. Another common interest was allegory and especially Martianus Capella, whose work was, again, often commented.[28] At the same time, anonymous *quadrivium* text collections were circulating; a mid-twelfth-century miscellany probably from Mont-Saint-Michel (Avranches 235) can serve to illustrate the new interests very well: the usually short excerpts treat much astronomy, geometry, and geography; Martianus is also quoted. One main theme is the astrolabe, its construction, and its uses.[29] So, both speculative Platonist and more practical scientific interests coalesced in the Chartres circle.

Its authors wrote texts of very different genres using very different Latin, from terse commentaries to poetical works. As an example of the latter, the highly artistic prosimetrum *Cosmographia* by Bernardus Silvestris (fl. 1148) may be mentioned. His approach is allegorical, and his language is often difficult. In another work (the *Mathematicus*), he rejects predictive astrology. Another key author is William of Conches (d. 1154), who already makes use of new translations of texts of medicine, geography, physics, and astronomy. His *De philosophia* in four books treats many sciences: after starting with invisible things (God, world soul, elements, demons), he proceeds to astronomy, apparitions in the air, and geogra-

27 The question of whether one should speak of a school was already approached by Southern (1970).

28 The standard work on myth and allegory is still Pépin (1976).

29 The manuscript is studied in depth in Callebat & Desbordes (2000).

phy, and ends with human anatomy, including reproduction. This relatively brief work makes many interesting points but does not usually dig very deep. It can be seen as a first attempt to digest the newly accessible learning. William also makes interesting methodological points, such as what teacher one should choose (*De philosophia* IV.33, ed. Maurach, p. 113):

> *Talis igitur ut doceat quaerendus est, qui neque causa laudis nec spe temporalis emolumenti, sed solo amore sapientiae doceat. [...] Sed si amore scientiae ad docendum accesserit, nec propter invidiam doctrinam subtrahet nec, ut aliquid extorqueat, veritatem cognitam fugiet nec, si deficiat multitudo sociorum, deficiet, sed ad instructionem sui et aliorum vigil et diligens fiet.*
> 'One should look for a teacher who does not teach for fame or for temporal profit, but for one who teaches only for the love of wisdom. [...] But if he approaches teaching for the love of science, he will not conceal things out of envy, nor will he flee the understanding of truth in order to make more money, nor will he leave if there is no great number of pupils, but he will remain alert and diligent in teaching himself and others.'

Later in life, William reworked the content into a didactic dialogue, the *Dragmaticon*,[30] in which he also corrected dogmatically dangerous points of view in his earlier work that had been pointed out in the meantime. His general approach and his language did not, however, change much. His language is not yet scholastic; indeed, he stresses (*De philosophia* I, prol., ed. Maurach, p. 16) that *sapientia* should be paired with *eloquentia* (quoting Cicero).[31] Many of the Chartres authors were also poets and allegorists, so although one can speak of an 'entdeckte Natur' ('discovered Nature'),[32] there was little interest in strictly scientific studies of individual phenomena; rather, the whole was always kept in view, in a typically Platonist manner. The important translator Hermann of Carinthia also figures among the Chartres pupils; his own work *De essentiis* uses a similar approach to William of Conches. Around 1200, Chartres is surpassed by the new university in Paris, which will be the centre of Latin intellectual life throughout the thirteenth century.

§5 As has already been mentioned, the medical school of Salerno was already established in the eleventh century, and with it a movement lasting more than a century of translating Arabic and Greek scientific and philosophical texts begins.[33] The above writers were still mostly outside the sphere of the new transla-

30 In I.1.8–11, ed. Ronca, pp. 7–9, he evaluates his earlier work.
31 More in Wetherbee (1972).
32 Cf. the title of Speer (1995).
33 The seminal work on the importance of the Salerno school was Kristeller (1945). Recent studies can be found in Jacquart & Paravicini Bagliani (2007); for a summary, see Jacquart (1993).

tions; indeed, it seems that the renewed interest in learning rather caused the translation movement than the other way round, although the latter certainly initiated a feedback loop. Before these translations could be carried out and become influential, Latin culture had to develop the necessary interest and audience. The previous sections have shown that new types of teaching and new interests had developed since at least the last quarter of the eleventh century. We are not well informed about the people who were the link between Latin scholars and Arabic learning. An exception is the Jewish convert Petrus Alfonsi (converted 1106), whose main work, the *Dialogus*, although concerned with the question of which religion is the best, uses both dialectics and results from many sciences in its argumentation.[34] In the currently rather vicious debate on the Arabic influence on Latin thought, many authors fail to distinguish between 'Arabic' and 'Muslim'. Interestingly, the Arabic authors Alfonsi quotes were all Christians and Jews;[35] Arabic culture and Islamic culture are two spheres that need to be kept apart in a meaningful discussion, although they obviously influenced one another.

Alfonsi was not a translator, strictly speaking, but others soon after him were. This twelfth-century translation movement[36] and its language must now be considered – a topic that is currently being studied widely, and many important texts are being edited for the first time. The importance of this wave of translations, first from Arabic and only slightly later directly from Greek, for a radical change in science and its language is obvious. The strongest impact – besides Euclid and medical texts – comes from Aristotelian works that had been unknown in the Latin West since Antiquity. A brief list of some of the most influential, known translators[37] will illustrate their geographic distribution.

- Constantinus Africanus (ca. 1020–1087), a Christian from Carthage, who moved to Salerno, translated medical texts from Arabic.
- James of Venice (fl. ca. 1125–1140), Constantinople, translated from Greek, especially Aristotle. The amount of manuscripts – going into the hundreds for many of his Aristotle translations, especially *Analytica posteriora, Metaphysica, and Physica* – shows his success.[38]

34 His sources are studied in Petrus Alfonsi, *Dialogus*, ed. Cardelle de Hartmann et al.
35 See the editors' remarks in *Dialogus*, vol. 2.
36 See D'Alverny (1982). De Leemans et al. (2017) now sum up what is known today about the translators and translations.
37 There must have been quite a number of other translators whose names are lost, among them some earlier quadruvial translators about whom we are badly informed, such as Lupitus of Barcelona (fl. 985).
38 See Minio Paluello (1972), with the few facts known about this translator.

- Adelard of Bath (fl. ca. 1130) travelled to Antioch;[39] he translated from Arabic, especially astronomy and mathematics. Among his own works, there is a dialogue *Naturales quaestiones*.
- Plato of Tivoli (fl. 1136), Catalonia, translated from Arabic – astronomy and astrology, especially Ptolemy.
- Burgundio of Pisa (ca. 1110–1193), a Pisan diplomat at the court of Constantinople, where he translated from Greek.[40] Among his translations are Aristotle, Galen, and legal works.
- Dominicus Gundissalvi (ca. 1110– after 1181) and John of Seville (fl. ca. 1150), Toledo, translated from Arabic, especially medicine (Avicenna) and alchemy.
- Gerard of Cremona (ca. 1114–1187), also Toledo, translated from Arabic – astronomy (including Ptolemy), mathematics, and theory of knowledge (al-Fārābī). He also translated the influential *Liber de causis,* a text at first sometimes attributed to Aristotle, but in reality excerpted from Proclus.
- Hermann of Carinthia (d. ca. 1160) travelled to Constantinople, Damascus, and Spain; he translated from Arabic, especially astrology. He mentioned Thierry of Chartres as his teacher.

This sample should be enough to show that the translations from Arabic were mostly made in the zones of Latin–Arabic contact: Spain,[41] southern Italy, and the Levant, which had become a contact zone through the Crusader States.[42] Those from Greek were mostly made in Constantinople. In the early thirteenth century, another generation of influential translators translated important works that had been overlooked in the first wave, as well as retranslating or reworking texts whose earlier translations seemed insufficient. The most important exponents of this second wave of translations were the following:

- Michael Scot (ca. 1175–1232?), Sicily, translated from Arabic – alchemy, Aristotelianism (Averroes).
- Robert Grosseteste (ca. 1175–1253), England, translated from Greek – theology, Aristotle.
- William of Moerbeke (ca. 1215–1286) held a Catholic bishopric in Corinth and translated from Greek. He translated nearly all the extant works of Aristotle.

39 Burnett (1997a, 2000; the latter on the rôle of Antioch).
40 See Classen (1974).
41 Al-Andalus had a long tradition of high-level Arabic learning initiated by ʿAbd-al-Raḥman II (r. 821–852); see chap. 9 §12 above.
42 Burnett (2009: part 4), especially on Antioch.

So, in this period, the Latin West again gains access to the surviving works of Aristotle, Euclid, Ptolemy, the *corpus Hippocraticum*, and many other medical texts, but also many astrological, magical, and alchemical texts from Late Antiquity or by Arabic authors. Much material we would now call pseudo-science and magic was also translated, especially in Spain, where translators made more translations of astrology than of anything else. It is interesting to note that the time from AD 500 to 1150 is the only time in Europe when neither a single horoscope nor any individual showing an open interest in horoscopic astrology is known.[43] Most Church Fathers had argued strongly against astronomical determinism.[44] It can be said that the Church Fathers had weeded out pagan astrological learning and that now some of the 'weeds' returned; on the other hand, astrology fit well into the scientific worldview and will have been seen as scientific, at least insofar as it did not contradict free will and thus interfere with theology. The same phenomenon of an influx of unscientific tendencies along with scientific material can again, and presumably in a worse ratio, be observed in the fifteenth century (see chap. 12 §§3–4 below). The importance of the influx of scientific texts in Arabic and Greek for Latin language and culture is certainly immense, but it still seems exaggerated and tendentious a claim to say that 'Latin became a scientific language through the encounter with Arabic',[45] thus overlooking both the internal development sketched above and the important translations directly from Greek.[46] This vast newly acquired intellectual material would be assimilated to Latin thought through the later twelfth and thirteenth centuries, giving rise to new ways of thinking and new modes of studying. But how did the translators cope linguistically with their material?

The early translators tended to follow Jerome's Bible translation and Boethius' Aristotle translation method, *verbum de verbo*, not *sensum de senso*, afraid that they might miss something crucial in the original.[47] Jerome did this because of the holiness of the biblical text, in which even the order of words is a 'mystery' (see chap. 9 §2); in the case of the scientific translators, there seems to have been a nearly equally great awe at work. Mercken studied this kind of trans-

43 See Juste (2020: 311).

44 e.g. Augustine, *De civitate Dei* V.1–7, ed. Hoffmann, vol. 1, pp. 209–221; Cassiodorus, *Institutiones* II.7.4, ed. Mynors, pp. 156–157.

45 As Gordin (2015b: 33) does.

46 Gouguenheim (2008) sparked a sometimes vicious and unworthy, heated controversy about the extent of the Arabic contribution, seen by Gouguenheim as negligible, in this new Latin Aristotelianism. For a review, pointing out shortcomings in the book in a balanced and scientific way and summing up the *status quaestionis* today, see Burnett (2008).

47 On these techniques, see Chiesa (1987).

lation Latin for Robert Grosseteste. He summarises (1981: 690): '(1) Each Greek word is rendered by a Latin counterpart; (2) the order of words is rigorously preserved; and (3) the syntax is faithfully reproduced in Latin.' This approach is the normal one for these translators; it produced a kind of Greek in Latin words that may be rather hard to understand, and certainly already was for students back then. Teachers and commentaries helped them assimilate the Greek way of thinking. One quite random example from Aristotle's *Analytica posteriora* (II.2, 90a31–34) illustrates this language:

> Ὥσπερ οὖν λέγομεν, τὸ τί ἐστιν εἰδέναι ταὐτό ἐστι καὶ διὰ τί ἐστιν. Τοῦτο δ᾽ ἢ ἁπλῶς καὶ μὴ τῶν ὑπαρχόντων τι, ἢ τῶν ὑπαρχόντων, οἷον ὅτι δύο ὀρθαί, ἢ ὅτι μεῖζον ἢ ἔλαττον.
> Sicut igitur diximus, quod quid est scire idem est et propter quid est. Hoc autem aut est simpliciter et non eorum que insunt aliquid est, aut que insunt, ut quoniam duo recti sunt, aut quoniam maius aut minus est. (James of Venice, ed. in *Aristoteles Latinus* 4.1–4, p. 71)
> 'As we said, then, to know the essence of a thing is the same as to know the cause of it. This is so whether the *subject* simply is, apart from being any of its *attributes*; or whether it is one of its *attributes*, e.g., *having the sum of its angles* equal to two right angles, or greater and smaller.' (Trans. Tredennick, pp. 179–181)

The quoted English translation adds quite a lot (italics) and turns nominal phrases into nouns, which makes the rather condensed text easily understandable but much longer, rendering for example τὸ τί ἐστιν as 'the essence of a thing'; διὰ τί ἐστιν becomes 'the cause of it'. James of Venice does quite the opposite and makes the text rather less understandable: typically, it becomes quite hard to tell what the demonstrative and relative pronouns point to. The translators, wishing to render the Greek one-to-one, had to solve the following main problems when translating from Greek.[48]

- Missing words. Attempted solution: neologisms, e.g. *quidditas*, *cognoscitivum;* mere transliterations (*dyapason*); or translating (near) synonyms with the same word, such as κύκλῳ φορά, κυκλοφορία, περίοδος, περιφέρεια, περιφερές, περιφορά, all translated by James as *circulatio*.
- Lack of easy compounding in Latin (see chap. 21 below). Sometimes new words (e.g. *deoformis* for θεοειδής),[49] even chimerae such as *eupraxia*, are attempted; otherwise, Greek compounds had to be rendered by Latin phrases.
- Missing grammatical structures, such as Greek aspects, many types of participles, dual, -περ, some particles. These are usually just lost in translation. But this is especially problematic in case of the article: τῶν ὄντων = *eorum que*

48 Examples from translations of Aristotle's *Physica*; details in Roelli (2014a: 948–949).
49 Example from Mercken (1981).

sunt or τοῦ ἐξ ἀνάγκης = *illius (eius) quod est ex necessitate* become very awkward.[50]

Kuhlmann (2002: 110) has pointed out that such *verbum de verbo* translations are not meant to be used as stand-alone texts; instead, they were often used with a commentary (*notulae* in case of Grosseteste). So they are very similar to what comparative linguists do today when they want to reproduce a text from another, often exotic, language as closely as possible. Below (chap. 22 §5), I translate a Sanskrit formulation of the Pythagorean theorem into very 'bad' *verbum de verbo* English as: 'Therefore of right-angled-triangle square of hypotenuse of the two-sides by square-adding equal becomes.' The aim is, of course, to reproduce the structure in the original language, not to write good style. The humanist criticism of this method, which completely misses this point, will be discussed below (chap. 13). In fact, this precise method of translation may be said to be of a markedly scientific nature, albeit one that produces 'bad' and not easily readable Latin. Clearly, the problems were even worse for translators who translated from Arabic, whose structure is very different.

§6 The translations produced a rapid development of many sciences in the second half of the twelfth century,[51] but the understanding of what science is was also revolutionised: for the first time in Greek or Latin, a clear and distinct category of demonstrative 'science' comprising many subbranches emerges, from now on always called *scientia*.[52] The two fundamental new texts for this were Aristotle's *Analytica posteriora* and al-Fārābī's *De scientiis*. The former had been translated for the first time into Latin by James of Venice,[53] then by several later translators (such as Gerard of Cremona); it details how science ought to be done.[54] Many commentaries were written on this work, and it was to shape the discussion on the nature of science in the centuries to follow, as we have seen

50 For attempts to remedy this problem, see chap. 24 §2.
51 'Überall sehen moderne Spezialisten der angesprochenen Disziplinen seit ca. 1150 Neues sprießen' ('Modern specialists in the mentioned disciplines see novelty sprouting everywhere from about AD 1150'; Rexroth 2011: 30).
52 Fidora speaks of a 'Revolution im Wissenschaftsverständnis' ('revolution in the understanding of what is science'; 2007: 13). Aristotle had not made a full division of the sciences; 'le problème de la classification des sciences n'a pas reçu d'Aristote une solution définitive' ('the problem of the classification of sciences did not receive a definitive solution from Aristotle'; Mariétan 1901: 47).
53 Four translations are edited in *Aristoteles Latinus*, vol. 4.
54 But see above on this work's unclear function for Aristotle himself (chap. 7 §5).

above (chap. 7).[55] The first known and surviving one is by Robert Grosseteste (whom we met as a translator above) around 1220; he included a detailed discussion of forms of knowledge (quoted in chap. 2 §4 above) and of the division of sciences.[56] We have seen (§1) that Hugh of St Victor had already attempted a new division of science; the second half of the twelfth century then gets a decisive impulse to make new divisions of the sciences[57] by the second text: Dominicus Gundissalvi translated the *Kitāb iḥṣāʾ al-ʿulūm = De scientiis* by the Arabic Aristotelian al-Fārābī (ca. 872–ca. 951) in the 1140s.[58] Gundissalvi also wrote his own work on the topic, *De divisione philosophiae*, which, however, is so strongly dependent on Fārābī that some manuscripts attribute it to the latter.[59] He follows Aristotle (cf. *Metaphysica* E1, 1026a) by distinguishing three main sciences (*De divisione philosophiae*, ed. Baur, p. 15):[60]

> *Unde Aristoteles: ideo scientiarum sunt species tres, quoniam una speculatur quod movetur et corrumpitur ut naturalis, et secunda quod movetur et non corrumpitur ut disciplinalis, tertia considerat quod nec movetur nec corrumpitur ut divina.*
> 'Therefore Aristotle says: thus there are three species of sciences: one contemplates what is movable and corruptible as natural science, the second what is movable and is not corruptible as mathematical science, the third what is neither movable nor corruptible as theology.'

Baur summarises the more complex classification as follows (edition, p. 193): *scientiae eloquentiae* (*grammatica*, *poetica*, *rhetorica*), *scientia media* (*logica*), *scientiae sapientiae* (*physica*, *mathematica*, *theologia*; *politica*, *oeconomica*, *ethica*).[61] This attempt to see science as an open edifice of interdependent scientific fields that Gundissalvi offers to his readers thus stems from Arabic Aristotelians, especially al-Fārābī. The criteria used to determine whether a field was a *scientia* (*ʿilm*, ἐπιστήμη) are already evident in the *Analytica posteriora*, but the consequent use of them to create such an edifice of sciences is an Arabic innovation; at least, I know of no similar approach in surviving Greek texts. In the later twelfth

55 In his introduction, Longeway (2007) details this development before and including William of Ockham.
56 *In Analyticam posteriorem* I.10–12, ed. Rossi, p. 170–198.
57 Grabmann (1957: 2:28–54) studied several of them; see also Burnett (1990).
58 Baur's edition, p. 164. On the text itself, see Jolivet (1997: esp. 258–264). Other Arabic authors also wrote about the classification of science besides al-Fārābī; the first who did so was al-Kindī (ca. 801–873), but most of his works concerning this topic are lost (Jolivet 1997: 255–258).
59 Stating: *alii putant quod sit Alpharabii* (ed. Baur, p. 160).
60 There is no exact counterpart in Aristotle. Fidora (2003: 104) thinks of *Physica* II.7, 198a29–31.
61 He also includes some fields we would not call scientific today, such as *scientia augurandi in volatu et a garritu avium* ('the science of observing omens in the flight and noises of birds'; ed. Baur, p. 120).

and the thirteenth centuries, similar texts become common, for example the anonymous *Tractatus quidam de philosophia et partibus*.[62] From now on, 'science' becomes a topic to write about, for instance for the Dominican Robert Kilwardby (ca. 1215–1279), who wrote an influential *De ortu scientiarum* (ed. Judy). Another influential work for the first time translated fully into Latin is Euclid's *Elementa*.[63] It is translated several times around the middle of the twelfth century (see chap. 22 and fig. 48), and it was to become very influential in shaping how deductive science should be done in the centuries to come. It is interesting to note that al-Fārābī's canon of sciences for the first time nearly exactly matches the one still used in German and other languages as *Wissenschaften* (see chap. 1 §1).

In university scholasticism, it will become a common approach that the author first tries to prove that his field is indeed a *scientia*. We have met this in Aquinas above (chap. 1 §6), when he proves that scholastic theology is a *scientia*. The speculative grammarian Radulphus Brito can serve as another example. He starts his *Quaestiones super Priscianum minorem* by establishing that *grammatica*, which means for him linguistics or *Sprachwissenschaft* in general, is a *scientia*. His proof shows (ed. Enders & Pinborg, vol. 1, p. 90):

> *Illa scientia est necessaria hominis sine qua nullam scientiam potest acquirere sive addiscere.*
> 'This science [of grammar] is necessary for men; without it, one can acquire or learn no other science.'

At the universities, *quaestiones* on the topic of whether something is a *scientia* or not become very widespread. A few examples:
- *An metaphysica sit scientia* (Richardus Rufus, d. ca. 1260, *Memoriale quaestionum in Metaphysicam Aristotelis* prol.).
- *Secundo, utrum sit scientia* (Thomas Aquinas, d. 1274, *Summa theologiae* Ia, q. 1, pr.)
- *Utrum de rebus naturalibus sit scientia* (Petrus de Alvernia, d. 1304).
- *Utrum theologia sit scientia* (Robert Holcot, d. 1349).
- *Utrum physica sit scientia* (Rudigerus Dole de Roermundia, d. 1409).[64]

But this is already part of the next chapter's topic. Giard (2009: 54) rightly summarises about the now standard term *scientia*:

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62 See van Steenberghen (1966: 60), and further Hugonnard-Roche (1984).
63 Its language is studied in chap. 22 below.
64 More examples in Lohr (1967–1973), searchable using https://www.academia.edu/37936210/Index_of_Incipits_to_Ch_H_Lohr_Medieval_Latin_Aristotle_Commentaries.

> Dans les universités, les commentaires scolastiques amplifieront et perpétueront cet usage de *scientia* au sens aristotélicien, tout en conservant, venue du latin chrétien, la tradition de réflexion sur la *scientia Dei*, connaissance parfaite des vérités éternelles en Dieu.
> ‘At the universities, scholastic commentaries will amplify and perpetuate this use of *scientia* in the Aristotelian sense, while preserving from Christian Latin the tradition of reflecting on the *scientia Dei*, the perfect knowledge of eternal truths in God.’

Relation to criteria for science

§7 Several new strands can be made out in this relatively short but crucial period. What may be called an encyclopaedic glossing movement can be seen at work in biblical studies, medicine, and jurisprudence. Late antique interests are taken up again: Aristotelian sciences, especially logic, from Boethius, Roman law from the Justinian collection, studies of the biblical *littera* on a comparable level to that of Jerome for the first time. In contrast to the résumés of the age before, the many new collections of data aimed rather at having important information concerning crucial texts in a readily available form with which further work could be undertaken; they were thus not an end in themselves of a merely didactic nature. At the same time, there is a higher esteem for logic and *ratio*, even in theology (Anselm of Canterbury, Abelard), but also a rebirth of mystic Platonism of the Eriugenian kind (Chartres circle). To all of this, from around AD 1130 onward, translations of many important scientific texts from Arabic and Greek were added, and with them what one may call a Greek scientific *Denkstil* becomes visible. This greater and more easily accessible amount of information will coalesce with Aristotelian logical and dialectical methods to yield scholasticism, treated in the next chapter. Many of the strands that have been mentioned do not square very well with the proposed criteria for science. Indeed, for science this epoch is rather one of preparation than of fulfilment. There is definitely a growing community effort at the various schools and institutions (V); the Platonists certainly build up a coherent whole world-picture (IV), but it is one that is usually hardly testable (III) and does not explain step-by-step (II). It is rather based on webs of allegories. On the other hand, the biblical and legal schools do develop systematic methods (I) and try to explain rationally step-by-step (II). Their efforts even lead to a growing formalisation (VI) that moves toward fruition in the next epoch. The precise translation style may also be said to be of a scientific nature, as was argued above.

Considering the richness of new approaches and institutions in this period, we might be tempted to follow Haskins (1933) in seeing the greatest caesura in European intellectual life in general, but also in the development of science, in the twelfth rather than in the late fifteenth century. It is indeed in the long twelfth century that for the first time Greek scientific thought is seriously emulated and assimilated in Latin. Nonetheless, it may be preferable to avoid the word 'renaissance', which may create confusion: some strands from Antiquity are taken up in both cases, but in neither case can there be any question of a rebirth of Antiquity: quite novel things evolve instead. The fact that the caesura of the long twelfth century is still much less appreciated will have to do with the humanist disdain for the 'Middle Ages' – a derogatory term they invented – which culminated with the 'scholastic' times they especially disliked, from the twelfth to the fifteenth century, a disdain that is only slowly being overcome.[65] In contrast, we ought to see the Latin phase of science between the twelfth century and roughly AD 1800 as one rich epoch of one largely organic development including three major subphases after the long twelfth century: scholasticism, Renaissance approaches, and 'revolutionary' science. These are the topics of the next three chapters.

65 The large and thorough *Histoire générale des sciences* (Taton 1958–1981) can serve as a good example: vol. 1 treats the entire time span up to the second half of the fifteenth century, vol. 2 from then to the eighteenth century (so roughly as long as science is done in Latin), vol. 3 the nineteenth and twentieth centuries.

11 University science: An Aristotelian Revolution

> Die europäische Universität in ihrer Fakultätenstruktur sollte wegen der institutionellen Verschränkung der Wahrheits- und der Nützlichkeitswissenschaften der entscheidende Faktor für die Emergenz 'der' Wissenschaft sein.
> 'The European university with its faculty structure would become the decisive factor for the emergence of science par excellence, because of the institutional intertwining of truth- and utility-based sciences.'
>
> Rexroth (2011: 49)

§1 In the early thirteenth century, several of the twelfth-century currents discussed in the previous chapter coalesced into higher education of a university type which combines useful subjects with speculative ones, as Rexroth in the quotation points out.[1] The twelfth-century translations of crucial texts had produced an awareness of a concept 'science' in an Aristotelian setting, which was now addressed as *scientia*: certain knowledge could be sought in many aspects of existence, leading to as many *scientiae*; many of them were studied at the new universities. At first there was only one such new school for each emerging faculty: Salerno for medicine (operating already in the late eleventh century), Bologna for law (from the middle of the twelfth century), and Paris for theology and the arts, that is, the more theoretical sciences (from ca. 1200). In the thirteenth century, they were joined by many others, among them Oxford, Cambridge, Montpellier, Padua, and Salamanca. Thus, this chapter will focus on science and these early universities.

The foundation of the University of Paris is certainly the most important event for 'scholasticism'. The year 1200, in which the French king granted the scholars and masters in the town a special legal status, is often used to demarcate its foundation.[2] The 'useful' subjects medicine and law had thrived already in the twelfth century at their specific institutions; in contrast, it was only now that the 'speculative' ones – the *artes*, philosophy, and theology – acquired important functions in society: the general education of an *artista* was required for many positions both at worldly courts and in the Church hierarchy. Indeed, law, medicine, theology, and – somewhat later – philosophy, growing out of the propaedeutic *artes libe-*

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1 The two groundbreaking works on early universities were Denifle (1885) and Rashdall (1936). Haskins (1972) and Pedersen (1997) are more up-to-date introductions; unfortunately, the latter is badly translated from the Danish, especially in the improbable spelling of proper names. Lately, there has been a renewed interest in the beginnings of the university in Paris: cf. Gorochov (2012); Verger (2013a); Verger & Weijers (2013), esp. Verger (2013b).

2 e.g. Kluxen (1981: 273); *OED* (s.v. 'university'): 'body of masters and scholars of an academic institution (from c1210 with reference to the University of Paris [...])'.

https://doi.org/10.1515/9783110745832-012

rales, were to remain the four standard faculties of higher education for centuries to come. Natural science would at first remain a branch of philosophy, still often called 'natural philosophy'. The *artes liberales* lived on in the artistic faculty at the very time when their shortcomings in encompassing all sciences were clearly seen. So, sciences such as physics, biology, or historiography had to be squeezed into this system as far as possible. Although universities arose at this time, there was no contemporary word for this new type of higher school. The word *universitas* simply meant the 'community (of masters or students)'.[3] The institution could best be described at the time as *studium generale*.[4] Such 'universities' may be characterised as schools (i) with more than local attendance, (ii) at which at least one of the higher faculties was taught (medicine, law, theology), and (iii) where teaching was done by a considerable number of masters (see fig. 19).[5]

Fig. 19: Teaching at the University of Paris, in Castres, Bibliothèque municipale, ms. 3, fol. 277r. Source: https://commons.wikimedia.org/wiki/File:Philo_mediev.jpg (image by user Vol de nuit, public domain).

3 In early modern times, the term was understood as *universitas litterarum* (or *disciplinarum, scientiarum*), as an institution that covered all scientific fields.

4 See Pedersen (1997).

5 Criteria from Rashdall (1936: 7).

We have seen in the previous chapter how the reception of Aristotle, especially the *Analytica posteriora*, changed the understanding of the nature of science fundamentally. The Arabic commentator Averroes, whose Aristotle commentaries were translated in the early thirteenth century, had assembled Aristotle's writings, providing an 'encyclopaedic structure and the philosophic principles' which became the standard at the University of Paris from the mid-thirteenth century onward: 'Working within this paradigm, the Latins made, in the course of the next two centuries, enormous progress in natural science' (Lohr 1997: 265). Some authors see the beginning of modern science at these universities.[6] Although this seems exaggerated (if we recall institutions and individuals treated above), there was definitely a greater number of people involved in science than ever before at these universities, producing an impetus to start an accelerating development in many sciences in the centuries to follow. The University of Paris's independence was acknowledged by the Pope in the bull *Parens scientiarum* (1231). The question of how far Aristotelianism was compatible with Christianity led to vivid discussions and several bans of some Aristotelian material[7] at the University of Paris by the bishops of Paris throughout the thirteenth century. Criticism came from monks and traditionalists, but also from within the new schools.[8] By the time William of Moerbeke had completed his translations, all the extant works of Aristotle had become available in Latin;[9] their digestion and adaptation to very different surroundings from Aristotle's would take some time. The commentaries of Averroes were also translated and became influential despite some of his positions being in conflict with Christianity, especially concerning the eternity of the world and the mortality of the soul. Roughly at the same time, the two mendicant orders were founded, became involved in teaching, and produced some outstanding scientists. The new order of Dominicus of Osma obtained papal approbation in 1216, that of Francis of Assisi in 1223. The philosophy of the Dominican Thomas Aquinas (1225–1274) soon became the accepted synthesis of Christian Aristotelianism, at least within his order.

After scholasticism as a 'scientific' approach is considered (§2), this chapter will provide examples of this Latin Aristotelianism of the late thirteenth and the first half of the fourteenth centuries, leading to philosophers with rather novel

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6 e.g. Honnefelder speaks of a 'Verwissenschaftlichung des spätantiken Bildungswesens' ('scientificisation of the late antique education system'; 2017: 46).

7 Including spurious texts; see Kraye et al. (1986), esp. Schmitt (1986).

8 See Ferruolo (1985).

9 The only exception seems to be the *Mechanica* (the authorship of Aristotle is disputed today). This work was to become important in the sixteenth century after being translated by Theodorus Gaza. See further de Leemans et al. (2017: 116).

and highly technical approaches, especially among authors in the two new orders (§§3–5); then the innovative scholastic language will be considered (§§6–7); and finally an excursus on later neo-scholasticism closes the chapter (§8). The crucial new element in this time is certainly Aristotelianism, so much so that we might be tempted to speak of an Aristotelian Revolution. The Black Death sweeping over Europe from 1346 to 1351 and killing a significant part of its population may be responsible for a slowing in intellectual development, which had been very fast in the two centuries before that time. In the fifteenth century, new approaches will develop; they are the topic of the next chapter.

§2 The universities' scientific approach is known as 'scholasticism'.[10] It grew out of several of the mentioned movements in the twelfth century, especially the new dialectic taught by Anselm and Abelard, and the newly available translated texts, especially the Aristotelian ones. Scholasticism can be described as a deductive scientific method whose aim is to gain new knowledge chiefly from a canon of authoritative texts by the use of logical rules – a method prepared by several of the twelfth-century approaches encountered in the previous chapter. Its first step is to understand an authoritative text, then to show that (despite appearances in some cases) it does not contain contradictions, and finally that it does not contradict evident facts or other texts considered authoritative. In a next step, logical implications are developed from these authoritative texts and the student learns to ask *quaestiones* arising from texts or circumstances in life and to weigh the authorities in order to solve them; *disputationes* will then show whether the understanding attained can stand up against others' points of view.[11] Thus, scholasticism is better not viewed as a certain kind of philosophy or a certain school, but rather as a *Denkstil*, a method for gaining knowledge with a strong emphasis on authoritative texts and logical rules.[12] Therefore, we can speak of neo-Platonic scholasticism, which based itself on Plato's texts as authoritative; and similar

10 The term σχολαστικός and its Latin counterpart *scholasticus* mean 'devoting one's leisure to learning', but already in Quintilian it often came to mean 'rhetorical' (what one learned in rhetorical school); soon the word could be used for any academic or 'scholar' and could also acquire the pejorative meaning 'pedant'. The terms 'scholastic' or 'scholasticism' are not used in the thirteenth century; they become common for the movement in question only in early modernity as pejorative terms with the connotations 'sophistic', 'schematic', 'unrhetorical', 'pedantic'.
11 On these methods of scholasticism, see Weijers (2020).
12 Grabmann defines scholasticism more narrowly as a purely theological method, striving 'durch die Vernunft […] die übernatürliche Wahrheit dem denkenden Menschengeiste näher zu bringen' ('through reason […] to bring the supernatural truth closer to the thinking human spirit'; 1957: 1:36). Our definition has the advantage of showing the similarities between various 'scholastic' movements in the history of mankind.

scholastic approaches can be discerned in India or Tibet.[13] This kind of scholastic *Denkstil* seems to be quite widespread among literate cultures. In the Christian Middle Ages, this school method developed around the most authoritative text for Christians: the Bible, besides also the writings of the most important Church Fathers, especially Augustine; but in the thirteenth century, the newly available *Corpus Aristotelicum* soon started to be treated in the same way by the Dominicans, especially Albertus Magnus and his pupil Thomas Aquinas. As a method, this scholasticism can be traced back to ancient dialectics, which had been taught all through the Middle Ages as one of the *artes liberales*.

§3 Some quotations from the Aristotelian approach of Aquinas have already been encountered (chap. 2 §4). His Aristotelian methodological approach would become very important in scholastic research and is still a main pillar of Catholic theology today. His language is especially well studied; there are even specialised dictionaries for it.[14] Two contemporary authors who used similar university approaches, but were more interested in natural science, will now be considered: Roger Bacon and Albertus Magnus. The Franciscan Roger Bacon (ca. 1219–ca. 1292) wrote three voluminous works at the request of Pope Clement IV on how the study of the sciences should be improved. Bacon pointed out that it would be more akin to Aristotle's way of practising science to follow his methods and not to treat his works as 'scripture'; he saw four main impediments to the furthering of understanding (*Opus maius* I.1, ed. Bridges, vol. 1, p. 2):

> *Quatuor vero sunt maxima comprehendendae veritatis offendicula, quae omnem quantumcunque sapientem impediunt, et vix aliquem permittunt ad verum titulum sapientiae pervenire, videlicet fragilis et indignae auctoritatis exemplum, consuetudinis diuturnitas, vulgi sensus imperiti, et propriae ignorantiae occultatio cum ostentatione sapientiae apparentis.*
> 'There are four main impediments to the comprehension of truth that hinder every man, no matter how great his wisdom; they hardly allow anybody to approach real wisdom. They are (i) the example of fragile and unworthy authority, (ii) the persistence of custom, (iii) the disposition of the ignorant multitude, and (iv) the concealment of one's own ignorance in order to show off feigned wisdom.'

13 This form of scholastic science (based on the glossing, commenting, and weighing up of authoritative texts), indeed, developed independently in India, as shown by Tubb & Boose (2007). The same wide definition is used, for instance, by Cabezón (1994), studying India and Tibet.

14 Most importantly Schütz. Some observations on the special vocabulary of Aquinas in Roelli (2013).

Besides these most human defects, Bacon argues for the importance of mathematics;[15] knowledge of foreign languages, especially for a direct knowledge of the Greek sources, not through translations;[16] and *scientia experimentalis:* science by experience, which he considers more important than authority (VI.1, vol. 2, p. 167):

> *Duo enim sunt modi cognoscendi, scilicet per argumentum et experimentum. Argumentum concludit et facit nos concedere conclusionem, sed non certificat neque removet dubitationem ut quiescat animus in intuitu veritatis, nisi eam inveniat via experientiae; quia multi habent argumenta ad scibilia, sed quia non habent experientiam, negligunt ea, nec vitant nociva nec persequuntur bona.*
> 'For there are two modes of gaining knowledge: by argument and by experience. Argument concludes and makes us accept the conclusion, but it does not make us certain and does not remove doubt so that our mind becomes satisfied in the apprehension of truth, unless it is found by means of experience. Because many have arguments about the knowable, but because they do not have experience, they neglect them and do not avoid what is injurious and do not seek the good.'

The *Opus maius* also contains a compendium of geography, astronomy, and optics, and ends with moral philosophy. After the untimely death of Pope Clement, Bacon lost support for his new approaches and spent the rest of his life in conflict with the authorities of his order. His interesting ideas were hardly realised.

Despite still often being heralded as the great forerunner of experimental science,[17] it would seem that not Roger Bacon but Albertus Magnus (ca. 1200–1280) was the greatest natural scientist of the century.[18] His works treat, among other matters, botany, zoology, mineralogy, physics, optics, nutrition, sleep, and old age, usually in the form of commentaries on Aristotle. His surviving works

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15 *Quoniam qui ignorat eam* [i.e. *scientiam mathematicam*] *non potest scire caeteras scientias nec res hujus mundi, ut probabo. Et, quod pejus est, homines eam ignorantes non percipiunt suam ignorantiam, et ideo remedium non quaerunt* ('That those who ignore mathematics cannot know the other sciences, nor the matters of this world, as I shall prove. And, what is worse, men ignoring it do not perceive their ignorance and thus do not seek a remedy'; IV.1.1, vol. 1, p. 97).

16 Discussed in part 3 of the *Opus maius*, condensed in *Opus tertium* 25, ed. Egel, pp. 180–194.

17 As mentioned above (chap. 3 §11), it is important to note that *experientia* and *experimentum* do not refer to 'experiment' – understood as a methodological putting of nature to the test to find out how things work – before early modern times, but rather to 'experience' in general.

18 This view is shared by Thorndike (1923–1958: 2:521). The Cologne critical edition has by now covered about half of Albert's works; for the others, Borgnet usually still needs to be consulted. See Hossfeld (1983) on Albert's scientific approach and Honnefelder (2011) on his approach to scientific education and work. See Draelants (2011) on the rôle of experience for him.

comprise some 8.6 million words.[19] Thorndike (1923–1958: 2:531–532) praises him thus:

> in his works on natural science Albert does not merely repeat past ideas whether of Aristotle or others, but adds chapters of his own drawn in large measure from his own observation, experience, and classification.

Indeed, he comments most Aristotelian works and often develops thoughts and observations further, often also making use of data provided by assistants. For instance, he finds out that there are no eels in the Danube and its tributaries, in contrast to other German rivers; or he doubts that ostriches can eat iron (as was apparently said of them) after repeatedly offering iron to one that would not eat it.[20] Experience can also be used to disprove Aristotle in some points (Thorndike 1923–1958: 2:547–548). He points out in his *Mineralia* (II.2.1, ed. Borgnet, vol. 5, p. 30):

> *Scientiae enim naturalis non est simpliciter narrata accipere, sed in rebus naturalibus inquirere causas.*
> 'It is not the matter of natural science to simply receive what is told, but to investigate the causes of natural phenomena.'

His investigations clearly made use of observations by craftsmen. For instance, in *Mineralia* (III.2.6, p. 82) he tells us that he contacted *fossores et depuratores metallorum* ('miners and purifiers of metals') as well as alchemists. Apparently, he even studied occultism on the basis of first-hand experience.[21] His commentary on Aristotle's *De animalibus* shows very well both his method and his acumen in observation and study,[22] characterised by Clara Wille (2017: 282) as being

> transmettre l'ensemble du savoir scientifique d'Aristote, l'adapter aux connaissances de son temps et le rendre accessible aux personnes instruites et moins instruites de son époque. Les limites de cette entreprise lui ont été imposées, entre autres, par la difficulté que comporte la version arabo-latine du texte aristotélicien.
> 'to transmit the whole of Aristotle's scientific knowledge, adapt it to the knowledge of his time, and make it accessible to the educated and less educated people of his time. The limits of this undertaking were imposed on him, among other things, by the difficulty of the Arabic-Latin version of the Aristotelian text.'

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19 Counted following Borgnet at http://albertusmagnus.uwaterloo.ca.

20 More examples and passages in Thorndike (1923–1958, 2:541).

21 Cf. *animae exutae a corporibus moveantur de loco ad locum; cuius veritatis etiam nos ipsi sumus experti in magicis (*'that souls deprived of a body move from place to place; we have experienced the truth of this ourselves in magic'; *De anima* I.2.6, ed. Stroick, vol. 7.1, p. 32).

22 See Pelster (1935).

Of course, despite a critical mind,[23] Albertus did often take over as facts things that seem implausible to us today (Thorndike lists examples), but this does not diminish the fact of his very scientific approach. He is clearly aware that the use of Aristotle's methodology will lead to insights that Aristotle had not yet known. He writes in the first version of his prologue to *De animalibus:*[24]

> *Sequemur autem Aristotelem secundum consuetudinem nostram [...] oportet nostrum librum prolixum fieri, qui et Aristotelis librum explanabit et nonnulla, que ipse non posuit, interponet, que scientie nunc videntur esse necessaria.*
> 'We shall follow Aristotle as is our custom [...] our book will needs have to become prolix, as it will explain Aristotle's book and add many things that he did not include but that seem necessary to science today.'

Hossfeld (1983) compared the advances in Albert's biology to what Aristotle had done. He collects passages where Albert observed new phenomena, and studies how he deals with them. For instance, for the *Historia animalium* he finds fifty-four observations that are Albert's own; of these, 'sind zwei von teils schlechter Qualität, enthalten 4 Phantastisches oder sogenanntes Jägerlatein, stellen mindestens 5 ausführliche Beobachtungen dar' ('two are of partly bad quality, four contain fantastic or cock-and-bull stories [literally "hunter's Latin"], and at least five are detailed observations'; Hossfeld 1983: 93). Hossfeld contrasts Albert negatively with Petrus Peregrinus, an author of whom very little is known and who wrote an interesting *Epistola de magnete* in 1269 (ed. Sturlese & Thomson). He describes many of his own scientific experiments in this small treatise. Hossfeld's rather negative general appraisal of Albert's scientific advances (1983: 96–98) seems too harsh. At least Albert had pupils and his approach was further developed in the centuries to come, whereas Petrus Peregrinus seems to have been an outsider, although the quality of his study of the magnet does seem to have been appreciated by some (thirty-nine extant manuscripts). The beginning of Albert's *De animalibus* will illustrate his scientific, scholastic language (I.1.1, ed. Stadler, vol. 1. p. 1):

> *Scientiam de animalibus secundum eam quam in principio praemisimus divisionem post scientiam de vegetabilibus in huius nostrae naturalis philosophiae calce ponemus: eo quod corpora*

23 e.g. Albertus writes about griffins: *Grifes aves esse magis tradunt historiae quam experta philosophorum vel rationes physicae* ('It is more story-books that relate that griffins are birds than the experience of philosophers or natural reasoning'; *De animalibus* XXIII.1.24, §112, ed. Stadler, vol. 2, p. 1494). Nonetheless, he lists what he was able to find out about these possibly unreal birds.

24 Quoted from Pelster (1935: 234).

animalium, de quibus loquimur, tam commixtione quam complexione quam etiam compositione constituentium commixtionem patiuntur elementorum in materia, complexionem autem sustinent humorum tam in generatione quam etiam in nutrimento: et membrorum habent compositionem ad regimen suae vitae pertinentem.

'We put the science of animals after that of plants at the foundation of our natural philosophy, as we announced in the division of sciences at the beginning, because the bodies of animals suffer a mixing of the material elements through mixing, combining, and also arranging of their constituents. They keep their combinations of humours both in procreation and in nutrition, and they have them arranged so as to fit their way of life.'[25]

The syntax is linear, the periods are connected by logical connectors, and relative clauses are common, but the vocabulary is complicated and technical; many nuances of technical terms are employed that are often hardly translatable. Scholastic scientific Latin is already fully developed in Albertus. Both its syntax and its approach to vocabulary look very Aristotelian, but in contrast to the 'Greek in Latin words' of the early translations his is rather a coherent new Latin style that differs strongly from classical rhetorical Latin but also from the translators' Latin, as this kind of Latin remained conformant with Latin's basic grammar and syntax.

Among Albertus' best disciples within the Dominican order was Dietrich of Freiberg (ca. 1250–ca. 1310), who studied many branches of natural science. His special interest was in light, optics, and colours. He wrote a detailed treatise on the rainbow. His way of arguing and his language can be illustrated with the following passage (*De iride* I.1, ed. Flasch, vol. 4, p. 123):

Impressiones, quae fiunt in alto huius elementalis regionis, duo sunt modi: Earum enim impressionum quaedam sunt naturales, quaedam autem radiales. Dico autem naturale, quae ex principiis naturae constant secundum proprietates physicarum qualitatum, quae sunt calidum, frigidum, umidum, siccum. [...] Radiales autem sunt, quae constant ex aliquibus irradiationibus corporum luminosorum in aliqua corpora talium irradiationum susceptiva.

'There are two kinds of impressions that happen in the upper strata of this elemental region: some of them are natural, some are radial. I call "natural" those that are present according to properties of physical qualities, which are hot, cold, wet, dry. [...] "Radial" are those that consist of some irradiations of luminous bodies into other bodies receptive to such irradiations.'

Dietrich complemented his treatises with geometric figures; he often quotes Aristotle and his *commentator* Averroes, but also Euclid.[26] The syntax is, again, very straightforward, the argumentation logical, the language in general similar to

25 In modern terminology: Albert describes living beings as stable systems despite a constant flux of matter through them. See Hünemörder (1980) on Albertus' zoology.

26 See the *index auctoritatum* invol. 4 of the *Opera omnia*.

that of Albertus. It is noteworthy that his approach is much more mathematical than Aristotle's; one can easily see Dietrich as a precursor of the Scientific Revolution several centuries after him.

§4 The new, greatly increased stock of knowledge both from the translations and from what was newly worked out at the universities led to another typical feature of this age: huge encyclopaedias.[27] Here, again, there are twelfth-century predecessors (such as Lambert of St Omer's *Liber floridus*), but of more modest size and often treating only a limited field. The three most important of these huge, general encyclopaedias of the thirteenth century are Thomas of Cantimpré's *De natura rerum* (ca. 1240, in twenty books), Bartholomaeus Anglicus' *De proprietatibus rerum* (ca. 1240, in nineteen books), and the largest of them all, Vincent of Beauvais's *Speculum maius* (ca. 1260, in eighty books).[28] It is divided into a *Speculum doctrinale, naturale,* and *historiale*. In these three parts, the author treats the *artes* in a very general manner (similar to that of Isidore in his *Etymologiae*), everything in nature (taken in a broad sense like William of Conches did), and world history respectively. At first the author envisaged only a *Speculum naturale* and *historiale*. Dissatisfied with this arrangement, he separated the former into matters pertaining to changeable nature and the timeless *artes*.[29] This wavering seems typical in times when the classification of philosophy, science, and learning was still much debated. Van den Abeele points out (2001: 551):

> Quest'abbondanza era strettamente connessa a vari sviluppi della storia intellettuale, in particolare la fine del periodo più intenso delle traduzioni in latino dall'arabo e dal greco, il rinnovamento scientifico che ne seguì, la nascita delle università, le iniziative degli ordini mendicanti che diedero impulso alla diffusione e all'organizzazione del sapere.
> 'This abundance was closely linked to some developments in intellectual history, in particular the end of the most intense period of translations from Arabic and Greek into Latin, the scientific renewal that followed, the birth of universities, the initiatives of the mendicant orders, all of which provided impetus for the dissemination and organisation of knowledge.'

The important defining characteristic of these texts is that they are 'systèmes de connaissance' ('systems of knowledge').[30] They provided new systematic working

27 For an introduction to them, see van den Abeele (2001). It must not be forgotten that this genre has its roots in times before the translations: Papias' alphabetical *Elementarium* was written between 1041 and 1063.
28 See Paulmier-Foucart (2004) and http://www.vincentiusbelvacensis.eu for a general introduction and a full bibliography.
29 See http://www.vincentiusbelvacensis.eu/works/SM-comp.html.
30 See Draelants (2013: 81–106).

aids for scholars. These encyclopaedias are usually thematic collections, and in the wake of the Chartrians (chap. 10 §4 above) their main interest is the universe and nature. Von Moos (1989: 1016) describes the new more scientific approach to learning:

> Une conception d'inspiration néoplatonicienne et stoïcienne très répandue au XII^{e} siècle: l'idée d'un langage originel, naturel, divinement inspiré, pur et vrai, dans lequel les mots désignent exactement les choses, et qui, au fil du temps, se serait peu à peu dégradé pour aboutir à un langage conventionnel, encombré de périphrases, métaphores et équivoques, à un langage 'connotatif', pour employer un terme contemporain. La science, dans cette conception, a pour objectif de restaurer, autant que possible, la parfaite *proprietas verborum* des origines paradisiaques, en établissant un langage clair et précis, donc 'dénotatif'.
> 'A conception of neo-Platonist and Stoic inspiration that was very widespread in the twelfth century: the idea of an original, natural, divinely inspired, pure and true language, in which words designate things precisely, and which, over time, would have gradually degenerated into conventional language, cluttered with periphrases, metaphors, and equivocations, a "connotative" language, to use a contemporary term. Science, in this conception, aims to restore, as far as possible, the perfect *proprietas verborum* of the paradisical origins, by establishing a clear and precise, therefore "denotative" language.'

Such an approach to scientific language can be seen as an important driving force for the genesis of scholastic Latin. Von Moos continues (1019):

> à la fin du XIIe siècle, le modèle de recherche et d'enseignement changea. L'autorité n'est plus la source dans laquelle on puise la vérité, mais un instrument qu'on utilise pour la trouver soi-même. Selon un mot d'Augustin souvent cité au XIIe siècle, l'autorité est un début, une aide pour les incultes; l'érudit la traverse comme une porte (une fois de plus cette métaphore), une porte qui le mène au travail de la raison discursive. Ce travail n'est plus solitaire, il s'accomplit en équipe, dans l'échange oral d'opinions divergentes, dans une dispute amicale qui s'approche peu à peu de la connaissance, sans nécessairement l'atteindre. En revanche, la simple transmission passive d'autorités acquises tombe en discrédit. [...] L'idéal de la méditation solitaire cède donc la place à l'idéal de la lutte commune sous forme d'un conflit ordonné et méthodique, qui, par la friction, fait jaillir les étincelles du savoir.
> 'at the end of the twelfth century, the model of research and teaching changed. Authority is no longer the source from which one draws truth, but an instrument one uses to find it oneself. According to a passage from Augustine, often quoted in the twelfth century, authority is a beginning, an aid for the uncultured; the scholar passes through it like a door (again this metaphor), a door that leads him to the work of discursive reason. This work is no longer solitary, it is carried out as a team, in the oral exchange of divergent opinions, in a friendly dispute that gradually approaches knowledge, without necessarily reaching it. On the other hand, the merely passive transmission of acquired authority falls into disrepute. [...] The ideal of solitary meditation thus gives way to the ideal of a common struggle in the form of an orderly and methodical conflict, which, through friction, emits sparks of knowledge.'

These ‘sparks of wisdom’ poetically point to our criterion (V) for science: a community effort that becomes much more widespread and organised at the universities and produces new ‘basic facts’ that subsequent science cannot ignore. Vincent’s work is a thematic collection of important passages from earlier writers, including Isidore’s *Etymologiae*. It seems that this enormous work tried to collect all the knowledge of its day as a kind of meta-encyclopaedia, a book that contains a library about all kinds of knowledge, but Vincent is conscious that he is not a *doctor* but rather a mere *excerptor* (*Apologia* 6, ed. Lusignan, pp. 121–122):[31]

> *Si quis autem presumptionis me uelit arguere, quod ego, non dicam in omni facultate uel arte, sed nec in una quidem satis edoctus, ausus sim etiam huic operi diuisiones omnium scientiarum et artium materiamque et ordinem singularum tam diligenter inserere, audiat iterum me non per modum doctoris uel tractatoris, sed per modum excerptoris ubique procedere, nec circa difficultates quarumlibet artium enucleandas propositum meum instituisse, sed levia quedam et plana de singulis memorieque utilia sub breuitate quadam ut cetera posuisse.*
> ‘If someone should wish to accuse me – who am not to be called erudite in all fields and arts, indeed not even enough in one – of having the presumption of daring to engage diligently in this work of the classification of all sciences and arts and in the matter and order of each of them, let him hear again that I proceed in all cases not in the manner of an expert or an author but of an excerpter, and that I did not fix my intention on enumerating the difficulties of all arts, but rather on briefly presenting some of the easier and plainer cases as well as ones useful for memorisation.’

Despite this, the author does speak for himself more than four hundred times in his *Speculum naturale* alone and reports in his own words. Of course, his language in these cases is less complicated than in the quoted preface. Both Vincent and Bartholomew were Franciscans. These long-ignored encyclopaedias have of late become a fertile field of study.[32] The IRHT Paris is currently working on digital editions of these important works.[33]

§5 In the early fourteenth century, the Franciscan Duns Scotus (ca. 1266–1308) is mainly famous as a theologian, but he ‘showed himself au courant with other scientific tendencies in his time’ (Thorndike 1923–1958: 3:3). In our context, he is especially important in forging new terminology which in many cases was to become established in philosophy. His interests concerned mostly metaphysical, theological, and logical problems. Eucken (1872: 68) mentions the following expressions he first observed in Duns: *actualitas*, *formalitas*, *haecceitas* (= *entitas*

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31 Similarly in *Speculum naturale*, versio SM trifaria (Duaci, 1624 edition), prol.
32 A large online bibliography collected by Isabelle Draelants can be found at the Atelier Vincent de Beauvais: https://ateliervdb.hypotheses.org/bibliographie-sur-lencyclopedisme-medieval.
33 http://sourcencyme.irht.cnrs.fr ; on the genre, see Draelants (2013).

positiva), *incompossibilitas*, *materialitas*, *perseitas*, *realitas*;[34] for the first time *objective* vs *subjective,* although in meaning quite contrary to the modern use; *esse reale* vs *intentionale*. Clearly, many of these terms have become fundamental in European philosophical language. Duns developed his technical language so far that his Latin is quite unintelligible for the non-specialist, as an example from his *Collationes oxonienses* (*Utrum vestigium sit*, *ratio quod sic*, q. 17.2, ed. Aliney & Fedeli, p. 225) illustrates:[35]

> *Dico quod omne quod habet esse preter primum componitur ex eo 'quod est' et 'quo est', scilicet ex esse 'quod est', vel ex aliquitate, et 'quo est', vel esse rei ratum. Est vestigium in re, et sicut esse est in eo 'quod est', ita vestigium est ratitudo, non aliquitas in qua fundatur.*
> 'I say that everything that has its own being, except the first, is composed of "that which it is" and "that by which it is", that is of the being "that is" or its somethingness, and being "by which it is" or certain being of a thing. The vestige is in the thing, and as being is in the "that is", so the vestige is the status as a thing [*ratitudo*], not somethingness in which it is founded.'

This short quotation alone contains the unusual technical terms *aliquitas* and *ratitudo,* besides many relative clauses and forms of *esse,* by now easily recognised as typical for scholastic Latin.

William of Ockham's (ca. 1287–1347, also a Franciscan) equally technical language can be illustrated with an excerpt in his discussion of what *scientia* is (*Ordinatio* prol. q. 1.8–11, ed. Gál et al., vol. 1, p. 320):[36]

> *Ad primum istorum dico quod scientia ad presens dupliciter accipitur. Uno modo pro collectione multorum pertinentium ad notitiam unius vel multorum determinatum ordinem habentium. Et scientia isto modo dicta continet tam notitiam incomplexam terminorum quam notitiam complexorum, et hoc principiorum et conclusionum; continet etiam reprobationes errorum et solutiones falsorum argumentorum; continet etiam divisiones necessarias et definitiones, ut frequenter. [...]. Alio modo accipitur scientia pro habitu existente per se in genere qualitatis, distincto contra alios modos habitus intellectuales, scilicet contra intellectum, sapientiam etc.*

34 See Mensching (2000) on some of these formations, especially *formalitas*.
35 The concept of *vestigium* ('trace') is defined by Aquinas thus: *vestigium, secundum quod hic dicitur, metaphorice accipitur, et sumitur ad similitudinem vestigii proprie dicti, quod est impressio quaedam confuse ducens in cognitionem alicuius, cum non repraesentet ipsum, nisi secundum partem, scilicet pedum et secundum inferiorem superficiem tantum* ('The term *vestigium*, as it is used here, is used metaphorically; it is applied due to the similarity of properly so-named traces [*vestigia*], which are some impression leading indistinctly to the cognisance of someone [who left the traces], [indistinctly] as it only represents him according to a part, that is of his feet and indeed only according to their lower surface'; *Super Sententias* I, d. 3, q. 2, a. 1, co., ed. Mandonnet, p. 100).
36 See Leff (1977).

> ‘Firstly, I say that “science” has presently two meanings. In one way as a collection of many things that belong to the knowledge of one or many things that have a well-defined order. And science in this sense contains both the knowledge of simple terms and the knowledge of complex ones, and this of principles and conclusions; it also contains the rejection of errors and the dissolution of wrong arguments; it usually also contains necessary divisions and definitions. [...] The other way “science” is understood is as a state existing in its own right in the *genus* “quality”, which can be distinguished from other such intellectual habits, such as understanding, wisdom, etc.’

So, Ockham clearly sees that the term *scientia* can be used for a systematic edifice of knowledge, ‘objectively’, as well as ‘subjectively’ of the person who has acquired it. This is an ambiguity valid in the languages descending from Latin but not in Greek, German, or Russian.[37] Although in these two authors the philosophical depth and the fineness of their semantic webs has further deepened since the earlier generation of Aquinas and Albertus, the syntax and the formulations still seem similar. It would be the same in the fifteenth century, when for instance Lambertus de Monte writes, a few years before 1500 (*De salute Aristotelis* §III 3.2.5, ed. Roelli, p. 207):

> *Primo quia secundum philosophos et secundum Arestotelem primo posteriorum, sciencia est universalium sicut enim universalium est definitio, ita et demonstratio cum definitio sit medium demonstrationis. Sed mundus est aliquid singulare, ergo non contingit proprie de ipso aliquid scibiliter cognosci. Secundo eius non potest esse proprie scientia cuius non potest sciri causa, cum omnis scientia sit per causam.*
> ‘Firstly, as according to philosophers and according to Aristotle in chapter 1 of the *Analytica posteriora*, science is of universals, in the same way as definitions are of universals, so also proofs, as the definition is the means of proof. But “the world” is alone of its kind, thus nothing can properly be scientifically known about it. Secondly, there can be no proper science of something of which the cause cannot be known, as all science is through causes.’

Thus, later scholastics such as Lambert still stress that *scientia* is of universals (thus not of perishable things) and that it seeks causes. In passing we note that an Aristotelian optimism regarding the possibilities of epistemology in the thirteenth century often gives way in the later Middle Ages to a rather more sceptical approach also inspired by Aristotle, this time by his *Topica*, using argumentation according to consensus (*sensus communis* or ἔνδοξον) in cases where certain knowledge cannot be attained (in this case, Aristotle’s fate in the afterlife).[38] It becomes clear that it took the Latins several centuries to ‘digest’ Aristotle, first to improve

37 See chap. 2 §3 above.
38 See Peter von Moos’s commentary in the edition, p. 29, and further especially von Moos (1988b); Ghisalberti (2013: 120–126).

some of his results, and then to start to improve his methodology too, something that starts in earnest with the next group of authors but is only accomplished in the time of the Scientific Revolution.

In fourteenth-century Oxford, new mathematical approaches to physical sciences were taken at Merton College. The most important scholars there were Thomas Bradwardine (ca. 1300–1349), William Heytesbury (1313–1372), Richard Swineshead (fl. 1350), and John Dumbleton (ca. 1310–ca. 1349), all of whom were *quadrivium* teachers; they are known collectively as the 'Oxford calculators'. They were able to build on the earlier work of Walter Burley (ca. 1275–1344).[39] Similar approaches were also developed on the Continent, centred on Paris, for instance by John Buridan (ca. 1300–ca. 1360), Nicolaus Oresmius (ca. 1320–1382), and Albert of Saxony (ca. 1320–1390). Their study of movement took its point of departure from Aristotle's *Physica*, but in contrast to him they tried to quantify physics. As an example of the technical yet still very scholastic language, an excerpt from Oresmius, *De proportione* 4 (ed. Grant, p. 262) can be quoted:

> *Quasdam propositiones de motibus in hoc quarto capitulo demonstrabo pro quibus sunt etiam alique suppositiones premittende. Prima sit hec: velocitas sequitur proportionem potentie motoris ad mobile seu ad resistentiam eius. Unde proportio unius velocitatis ad alteram est sicut proportio proportionis potentie unius motoris ad suum mobile ad proportionem proportionis alterius motoris ad suum mobile. Ista suppositio patet per Aristotelem secundo celi et per Commentatorem ibidem, et quarto et septimo phisicorum.*
> 'In this fourth chapter, I shall demonstrate some propositions about motion for which some suppositions have to be noted first. The first: velocity follows the ratio of the mover's power to what is mobile or to its resistance. Thus, the ratio of one velocity to another is the same as the ratio of the ratio of the other mover to its mobile. This supposition is evident from Aristotle, *De caelo*, book II, and from the Commentator [Averroes] thereon, as well as from his *Physica*, books IV and VII.'[40]

Oresmius also developed the notion of fractional powers and formalised them in a new kind of notation.[41] These authors changed the more logic-based Aristotelian physics by introducing quantities such as velocity, acceleration, or inertia, thus bridging the gap between the scholastic authors of the thirteenth century and Kepler, Galileo, and Newton;[42] the intervening humanist movement would lead to various changes where Latin style was concerned.

39 See Sylla (1982); Thijssen (2001).
40 Grant, *ad loc.*, points out that this rather awkward formulation amounts to $F2/R2 = (F1/R1)^{v2/v1}$ in modern notation.
41 See Cajori (1928–1930: 1:91–92).
42 See Crombie (1996: 441) and in general Grant (1996) on these predecessors of the Scientific Revolution.

§6 This new international organisation of higher education develops its own, very distinctive style and type of scientific language. Of course, the special character of this type of scholastic Latin has been noted not only by angry humanists but also by modern linguists. Springhetti (*Latinitas fontium*, pp. 83–87) describes the scholastic language in his Latin manual thus:

> *Est lingua scholae, [...] igitur artificialis et docta, technica et abstracta, [...] abhorret a sermone figurato, [...] magna ex parte desumpta ex Aristotelis versionibus, [...] mire fecunda, sive in vocabulis creandis, sive in eorum significationibus ampliandis, sive in ditandis recentioribus linguis magna vocabulorum propriorum copia.*
> 'It is the language of the schools; [...] thus artificial and erudite, technical and abstract; [...] it shirks from figurative usage; [...] it is largely taken from the Aristotle translations; [...] it is amazingly fertile, be it in creating new words, in enlarging their meanings, or in enriching the modern languages with the great wealth of its specific vocabulary.'

And Weijers (1996: 139) writes:

> Bref, le latin 'scholastique', influencé sans doute par le grec et l'arabe par l'intermédiaire des traductions, mais forgé et inventé aussi par des générations de maîtres universitaires, fut une langue jeune et fléxible.
> 'In short, "scholastic" Latin, undoubtedly influenced by Greek and Arabic through the translations, but also forged and invented by generations of university masters, was a young and flexible language.'

She further elaborates on this young and flexible language as using a 'logical' syntax, in which parts of the sentence that belong logically together are close to one another (as in the vernaculars, in contrast to rhetorical Latin), and showing a high degree of standardisation (it is indistinguishable all over Europe) as a technical language whose new *termini technici* are often loans from the translations of Greek texts (*quidditas, entitas, compossibilis, aseitas*, etc.) but can also be newly coined Latin words such as *contradistinguere*. This kind of language is characterised more fully by Stotz:

> Geprägt wurde diese Form der Latinität von der wissenschaftlichen Umgangs- und Debattiersprache, welche einfach und durchsichtig im Bau sein mußte. Im Zusammenhang mit der Rezeption der Schriften des Aristoteles und der arabischen Wissenschaft drangen nicht nur zahlreiche neue Fremdwörter ins Lateinische ein [...], sondern dessen Ausdrucksmöglichkeiten wurden auch durch viele inner-lateinische Neubildungen erweitert [...]. Die verschiedenen Wortkategorien, die durch Ableitung von andern Kategorien gebildet wurden, traten zu Systemen zusammen, welche die Systeme der durch sie belegten logischen Begriffe analog abbildeten. Der einzelne Ausdruck hatte in der jeweiligen Anwendung unmißverständlich und seiner Bildung nach durchsichtig zu sein. Zur Verknüpfung der Begriffe wurden nur einfache und logisch eindeutige syntaktische Verfahren zugelassen. Beispielshalber wurden

Partizipialkonstruktionen, deren feinerer logischer Gehalt ja oft nicht klar zutage tritt, gemieden. Umgekehrt haben sich ausgesprochene Modesuffixe und auch Modekonstruktionen herausgebildet. Das Neue an der hier zutage tretenden Haltung war, daß nicht mehr ein der überlieferten Sprache verhaftetes Denken, in Auseinandersetzung mit den Tiefen dieser Sprache, seiner selbst ansichtig wurde, sondern daß nunmehr mit deren Elementen so umgegangen wurde, als wäre sie eben erst dazu erfunden worden, zu den gedachten abstrakten Begriffen, sowie zu deren logischen Bezügen untereinander, je einzeln einen genauen Abklatsch zu liefern. Der einstmals gewachsenen Sprache wurde eine neue Art der Verfügbarkeit aufgenötigt, und sie wurde dadurch grundlegend verändert. (Stotz 1996–2004: I, §7.5 = vol. 1, p. 21)
'This form of Latinity was shaped by the scientific language of colloquy and debate, which had to be simple and transparent in construction. In connection with the reception of Aristotle's writings and Arabic science, not only did numerous new foreign words enter Latin [...], but its expressive capabilities were also enhanced by many new coinings within Latin [...]. The various categories of words which had been formed by derivation from other categories came together to form systems which analogously mapped the systems of the logical terms they represented. The individual expression had to be unambiguous in its application in any given case and transparent in its formation. Only simple and logically unambiguous syntactic procedures were allowed for linking terms. For instance, participial constructions, whose finer logical nexuses are often not clearly evident, were avoided. Conversely, decidedly fashionable suffixes and fashionable constructions developed. What was new about the attitude that comes to light here was that it was no longer a thinking that realised itself clinging to traditional language, in confrontation with the depths of that language, but that its constituents were now handled as if it had only been invented in the first place to provide an exact reproduction of the abstract concepts and their logical relationships to each other. A new kind of availability was forced upon a language that had hitherto grown naturally; by this it was fundamentally altered.'
Das unmittelbare Interesse an der Äußerung der Inhalte als solcher überwog hier deutlich dasjenige an der Pflege des sprachlichen Ausdrucks. Befreit von manchen Hemmungen und mit dem Ziel der unmittelbaren Erfassung jedes Einzelbegriffs, entwickelte man die lexikalische Seite der Sprache zu beträchtlicher Feingliedrigkeit; demgegenüber wurde die Syntax auf eine verhältnismäßig geringe Zahl von Formulierungsmustern eingegrenzt. Es kam zu dem Vorwalten eines ausgesprochenen Nominalstils. Dadurch nimmt diese durchweg zweckgerichtete Sprache einen verhältnismäßig einfachen und einheitlichen Bau an, angemessen dem mündlichen Gebrauch in Disputationen und der Aufnahme durch das Ohr in Vorlesungen, und gerade auch dadurch geeignet zur Weiterverbreitung. Allerdings lassen sich bei der Ausformung dieses sprachlichen Registers auch Abstufungen und Mischformen erkennen.[43] (I, §46.2 = vol. 1, p. 122)
'The immediate interest in expressing the content as such clearly outweighed the interest in cultivating linguistic expression. Liberated from many inhibitions and with the aim of directly capturing each individual term, the lexical side of language was developed with considerable subtlety; in contrast, syntax was restricted to a relatively small number of formula-

43 Some more linguistic details typical for scholastic Latin are listed in Stotz (1996–2004: I, §46.3 = vol. 1, p. 122), especially the syntagms *dicendum quod sic/non*, the article *li/ly*, question particles such as *an*, verbal adjectives in *-ivus* with *genitivus obiectivus*.

> tion patterns. The result was the predominance of a pronounced nominal style. As a result, this consistently purpose-oriented language takes on a relatively simple and uniform structure, appropriate for oral use in disputations and for reception by ear in lectures, and thus also suitable for further proliferation. However, in the formation of this linguistic register, gradations and mixed forms can also be observed.'

Recalling the above characterisation of the language of the translators (chap. 10 §5), it becomes immediately evident that scholastic Latin was largely modelled on it. This kind of language was clearly very much alive at Europe's early universities.[44] It is the strongest divergence from 'normal' Latin hitherto encountered among scientific authors. We might even speak of quite conscious language engineering that affected not only vocabulary but to some extent also syntax, as the characterisations above show; the syntax is conspicuous in its simplicity, very much like today's English of the natural sciences. Its extensive special vocabulary was described by Schütz for Thomas Aquinas in a comprehensive lexicon (the *Thomas-Lexikon*), useful also beyond Aquinas. The new approach and its desire to be able to express every οὐσία in one word (as Stotz points out) made suffixation very common. This will have been a consequence of Latin's inability to form ad hoc 'nouns' with the article and to compound freely as the Greek texts that sparked this movement could.[45] This new type of language consisting of simple syntax and a wealth of newly coined words caused a backlash in the Renaissance, as humanists came to see it as ugly and sophistic. In the numerical data below (chap. 18), the Latin language used by scholastic authors will be the one most easily set apart from all the rest.

§7 The extremes of scholastic language became the target of parodistic humanist works, such as the *Epistolae virorum obscurorum* – a collection of fictitious letters from in-famous (*obscurus* ≠ *clarus*) men written by humanists in the late 1510s.[46] These infamous men are uneducated mendicants, who often held high offices and played important rôles, especially in the Inquisition, not so much the traditional scholastic theologians themselves. Thus, the language under attack is somewhat different from that of Albertus or Aquinas or even Ockham. In particular, this parody uses many non-Latin words, especially German ones (*czechare* = *zechen*), but

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44 See chap. 16 §1 below for a discussion of what constitutes living and dead languages. Stotz (1996–2004: I, §64 = vol. 1, pp. 153–154) also considers the aspect of spoken university language in this kind of Latin.

45 This topic is further explored in chap. 24 below.

46 The historical background of this collection was a dispute between the humanist Johann Reuchlin and Dominicans, followers of the Jewish convert Johannes Pfefferkorn, who wanted to burn all copies of the Jewish Talmud.

also Romance ones (*adminus* = *au moins*), which is something educated scholastic teachers hardly ever did, but there are also many new Latin words, often formed badly or in an exaggerated way that makes them sound funny.[47] The authors especially parody suffixation.[48] Very common are -*alis* (e.g. *bibalia, coqualia, irreverentialis, rhetoricalis*), -*ivus* (e.g. *offensivus*, *scandalizativus, stimulativus*), and -*osus* (e.g. *incommodosus, solatiosus, scientiosus*),[49] but there are also many other suffix coinings: *argumentifex, convivalitas, inimicator, ignorax, fallimonia, gratiabilis*. They also invent meanings such as *scalare* ('throw down the stairs'; I.46, ed. Saladin, p. 325), or *discholus* ('bad student'; I.7, p. 155), and constantly use *unus* as an article. Although this language is obviously exaggerated, it becomes clear how permissive Latin had become for ad hoc coinings, for instance when Luther – who can certainly not be accused of being a scholastic – says *homo totus gloriaceus, glorianus, gloriensis et gloriosus*.[50]

It was felt by humanist authors, treated in the next chapter, that this technical scholastic language had more and more deteriorated into mere pedantry which only stifled the acquisition of new knowledge. New scholastic coinings, such as those just described, became targets of hefty criticism by humanists because of their lack of *latinitas* and later on by rationalists for an alleged lack of content. In the so-called age of reason, scholasticism was to become synonymous with empty but complicated formulations. Descartes expressed this feeling in a typical manner when he wrote against the scholastic theologian Gisbertus Voetius, who as rector at Utrecht University had condemned Descartes's teachings in 1642 (*Ad Voetium* IV, 1649–1650 edition, p. 27):[51]

> *Prima ex istis artibus est puerilis illa Dialectica, [...] perfacile enim illis est considerare separatim rei cujuslibet propositae nomen, definitionem, genus, species, similitudines, differentias, contraria, adjuncta, antecedentia, consequentia, & reliqua ejusmodi, quae vulgò in Topicis recensentur.*
> 'First among these arts is puerile dialectic, [...] it is very easy for them to consider for any proposed matter separately the name, definition, genus, species, similarities, differences, contraries, adjuncts, antecedents, consequences, and the other similar concepts that are commonly associated with the [Aristotelian] topics.'

Describing scholastics as puerile and lacking in discerning reason, Descartes goes on to argue that they can talk endlessly and defend any proposition and are thus

47 This work's language was studied by Löfstedt (1983), whom I follow here.
48 Examples from Löfstedt (1983: 281–283).
49 See our figures for these and similar suffixes in chap. 18 §4 below.
50 Quoted by Löfstedt (1983: 283).
51 See Woo (2013) on the circumstances.

mere sophists. Leibniz (1872b: 218) goes even further, inculpating the Latin language itself: after stressing the advantage of German in not being able to recycle Latin words as easily as the Romance languages and English can, he goes on to claim: 'was aber sich nicht in guth Teutsch geben läßt, bestehet gemeiniglich in leeren worthen und gehöret zu der Scholastik' ('what cannot be expressed in good German, however, consists only of empty words and belongs to scholasticism').[52] It thus took half a millennium for scholastic Latin to become empty and sterile in the eyes of some of the then greatest scholars, but as Thorndike (1923–1958: 2:971) rightly concludes, this Latin should rather be praised for its attempt at describing things in an orderly, clear, detailed, and systematic way:

> the scholastics presented their material in a more systematic way than classical writers, [...] the Latin of the thirteenth century has a clearer style and shows more direct thinking than the vernaculars of the fifteenth century.

The influence of this scholastic language on the emerging vernacular languages of science is certainly immense, although it has not to date been studied in depth. The Romance vernaculars and English usually just take over Latin technical terminology by applying some sound changes to it (for examples, see the list in chap. 23 §3), and even syntax becomes much more Latin in these vernacular languages, even in the only distantly related German, toward the end of the Middle Ages.[53]

§8 Some alternatives to this scholasticism are considered in the following chapters, but it should already be pointed out here that scholasticism did not succumb to humanist and empiricist attacks. In fact, a second, or neo-, scholasticism[54] endeavouring to rid itself of these criticised vices reached a new pinnacle in Salamanca in the late sixteenth and seventeenth centuries. The Dominican Francisco de Vitoria (ca. 1483–1546) can be seen as having founded this movement when he introduced the *Summa theologiae* of Thomas Aquinas as the base text for students of theology. The nearby Portuguese University of Coimbra soon followed. The professors involved in Salamanca were mostly Dominicans, those in Coimbra Jesuits. Thomistic philosophy was adapted to the new times, and juristic and economic problems were studied besides theological and philosophical ones. One of the

52 Three centuries after Leibniz, it is hardly necessary to quote examples of German texts that are even more empty than the worst scholastic Latin could ever have been.

53 See chap. 12 §1 below for more details.

54 The term 'neo-scholasticism' is sometimes used for a Roman Catholic movement of the nineteenth century initiated by Gaetano Sanseverino (1811–1865). This movement did not use Latin any more and has nothing to do with the present movement.

most important scholars was the Jesuit Francisco Suárez (1548–1617),[55] known as the *doctor eximius*. He first taught in Salamanca, then in Coimbra. His enormous amount of writing is still completely in Latin. His main work alone, the *Disputationes metaphysicae* (Salamantica, 1597), comprises 1.4 million words; it may be the first attempt at a systematic study of metaphysics since Aristotle.[56] The influence of this second scholasticism is still very much understudied, but it is obvious that these authors were read and used by the vernacular philosophers of their time and that their influence on the development of important novel scientific branches, for example of international law, was very significant indeed.[57] It may be due to their linguistic choice of using Latin that these authors are quite forgotten today. Their form of Latin keeps much of its scholastic virtues while avoiding the vices pointed out by the humanists, but in many fields the scientific methods have changed quite drastically. As an example, an excerpt from Suárez is quoted, where he argues that metaphysics is a science and tries to define its topic (*Disputationes metaphysicae* I.1.26, ed. Berton, vol. 25, p. 11):

> *Dicendum est ergo ens in quantum ens reale esse obiectum adaequatum huius scientiae. Haec est sententia Aristotelis, IV Metaph., fere in principio, quam ibi D. Thomas, Alensis, Scotus, Albert., Alex. Aphrod., et fere alii sequuntur, et Comment. ibi, et lib. III, comm. 14, et lib. XII, comm. 1; Avicen., lib. I suae Metaph., c. 1; Sonc., IV Metaph., q. 10; Aegid., lib. I, q. 5, et reliqui fere scriptores. Probataque est haec assertio ex dictis hactenus contra reliquas sententias. Ostensum est enim obiectum adaequatum huius scientiae debere comprehendere Deum et alias substantias immateriales, non tamen solas illas. Item debere comprehendere non tantum substantias, sed etiam accidentia realia, non tamen entia rationis et omnino per accidens; sed huiusmodi obiectum nullum aliud esse potest praeter ens ut sic; ergo illud est obiectum adaequatum.*
>
> 'Thus it must be said that being as real being is the adequate topic of this science [metaphysics]. This is the opinion of Aristotle (*Metaphysica* Γ, nearly at the beginning), which Aquinas, Alexander of Hales, Duns Scotus, Albertus Magnus, Alexander of Aphrodisias, and most others follow; cf. also Averroes on this locus and book III, commentary 14 and book XII, commentary 1, besides Avicenna (book I of his *Metaphysica*, chapter 1), Soncinas [Paulus Barbus] (*Metaphysica* IV, q. 10), Aegidius of Rome (I, q. 5), and most other writers. And this opinion is proved by what has already been said against other opinions. It has been shown that the appropriate object of this science must comprehend God and other immaterial substances, but not only them. Likewise, not only substances but also real accidents; but not what exists in reason and exclusively *per accidens*. But such a topic cannot be anything else than being as such [*ens ut sic*]. Thus it is the appropriate topic.'

55 Pereira (2007); Poncela González (2015).

56 In the meantime, metaphysics was usually practised more or less closely following Aristotle's work.

57 Especially through its further development by Hugo Grotius in his *De iure belli ac pacis* (Parisiis, 1625).

We see some typically modern, scholarly features here: literature and predecessors are cited, usually including the chapter as well as the work, and the argumentation is very logically structured. The content is less rigidly arranged than in, say, Aquinas, but the language still looks similar, although with hardly any unusual, non-classical words, as a glance at the Corpus Corporum lemma list for this text shows. Words such as *ens* had, of course, long since become fully naturalised in philosophical Latin.

Relation to criteria for science

§9 The introduction to this chapter hailed this time of an Aristotelian Revolution as the true birth of Latin science. Indeed, if we attempt to apply our proposed criteria, it becomes clear that methodological considerations are very common and in many fields systematic methods are developed and used (I). Authors such as Albertus often explain phenomena step-by-step (II); Bacon's *scientia experimentalis* aimed at testability (although it was hardly implemented); there were statements by Albertus that were meant to be testable as well as questions he resolved by testing done by himself (III). The worldviews of an Aquinas or Albertus do form a coherent whole (IV), and in fact one that is further developed by later authors such as Duns Scotus and Ockham. Albertus' specific interest in natural science is continued in his school, for example by Dietrich of Freiberg. In general, there is a growing community of people interested in scientific study; at the new universities, they have a space to meet, discuss, and further develop their approaches, and to teach them to younger generations. The two new mendicant orders further help to reorganise teaching (V); indeed, they often disagree and there is a (usually) healthy culture of disputation among them. Finally, in Albertus and Aquinas we can already observe an unprecedented formalisation of the Latin language that led to the very distinctive scholastic Latin. Among the Oxford calculators, mathematical language becomes more technical and new kinds of notation are invented; it is tempting to speak of a nascent mathematical formalisation (VI). The scholastic *Denkstil* seems to be weakest in empirical testing (III), despite the exceptions that have been mentioned, which is a common reproach of later authors of the Scientific Revolution.

It is interesting to examine scholastic Latin briefly in terms of the criteria proposed above for a language of science (chap. 4 §7). The definition of terminology (i) is already a major concern for Aquinas,[58] including the lack of ambiguity. Fol-

58 The lemma *definitio* occurs 2,308 times in the Corpus Thomisticum (https://www.corpusthomisticum.org), i.e. 0.28‰ or 4 times more than the average in Corpus Corporum.

lowing Aristotle, Aquinas often solves questions by pointing out that a Latin term is used in a polysemous way (ii). It was shown that scholastic terminology is easily extendable and flexible, to such a degree, in fact, that humanists will protest against its 'ugliness' (iii). It will be equally obvious that this language tried to be perspicuous: the syntax is usually linear and clear (again, this is considered inelegant by humanists). Much use is made of the existing Latin possibilities for expressing evidentiality (mostly subjunctives and adverbs), but no new methods were developed (v).

With scholasticism, Aristotelianism and the Greek scientific *Denkstil* have finally found their way into Latin culture. The next chapter will explore humanistic criticism of the allegedly 'ugly' formal language, pedantry, and pseudo-erudition that can be hidden behind technical language. Then, in chapter 13, we will see the adherents of the 'New Science' advancing the criticism that the rôle of experience and of mathematics was insufficient in scholastic science. The humanists' arguments can be advanced against any form of advanced science, and quite in general seem to be the stock arguments of traditionalists afraid of complicated and 'unnecessary' innovation. The new scientists' argumentation is more to the core. But the mathematical and technical *instrumentarium* simply did not yet exist in scholastic times; in fact, it was through scholastic science that the foundations for these necessary advances were laid by scholars like the Oxford calculators.

12 New approaches in the Renaissance

> From the scientific point of view the Renaissance was not a renaissance.
>
> Sarton (1929: 76)

§1 The term 'Renaissance', intended as a rebirth of Antiquity, was first used in art, although as late as the mid-sixteenth century, by Giorgio Vasari.[1] Moreover, it was only Jacob Burckhardt's epoch-making work *Die Cultur der Renaissance in Italien* (1860) that paved the way for the introduction of a completely new epoch in all facets of life emerging in fifteenth-century Italy, one that tried to renew and emulate Roman Antiquity. His approach has been much criticised in the past few decades; indeed, even the fact that many leading Renaissance men were members of the clergy should have alerted scholars to the fact that they did not intend to resurrect ancient Rome in all its facets, which would have included pagan religion. Even so, it does still make sense to have a new epoch begin in fifteenth century, as in this time many external parameters changed that were bound to influence people's perception of themselves and their relation to the past. The most important of these were the immigration of Greeks to Italy (in 1453 Constantinople fell to the Ottomans); the invention of the printing press (Gutenberg from 1455),[2] accelerating the circulation of new ideas decidedly; the new republican state forms in Italy, in which a new, flourishing literate middle class engaged in trade; and, in connection with this knowledge of foreign places, the *reconquista* of the Iberian peninsula (completed in 1492). This led to the age of discoveries: Bartolomeu Dias sailed around Africa in 1488, Columbus landed in the New World in 1492, Vasco da Gama reached India in 1498, and Fernão de Magalhães, finally, sailed around the world in 1522.[3]

The term 'Renaissance humanism' is used in order to emphasise the new picture of man emerging in this time.[4] This entailed the possibility of forming man to true humanity by means of classical studies (and, in contrast to earlier similar attempts, outside the Church). Humanism was at its core a rhetorical and pedagogical movement, seeking to move away from 'un-Latin' and unrhetorical scholastic language and back to Ciceronian purity of language and thought. Many humanists were themselves teachers or wrote textbooks and translations intended to supplant the 'barbarous', 'mediaeval' material available. A high appreciation of Greek culture came as a by-product of emulating classical Roman erudition. The

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1 See *OED* (s.v. 'renaissance').
2 See Eisenstein (1979); White (2017).
3 More on these matters in chap. 13 §3.
4 For this topic, see Kristeller (1961).

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Renaissance may, indeed, be said to depend in a certain sense on the fall of the Byzantine Empire and the immigration of Greek scholars to Italy in the decades before it. These scholars were heirs of the Palaeologan 'Renaissance', which revived learning in the last two centuries of Byzantium and produced scholars like Manuel Chrysolaras (1353–1417), Johannes Argyropoulos (ca. 1415–1487), Constantine Lascaris (1434–1501), or Cardinal Bessarion (1403–1472), who all emigrated to Italy and sparked enthusiastic interest there for Greek Antiquity – including its literature, superstitions, magic, and also science. Some humanists not only used Greek words and phrases in their texts – which was already a common practice among some mediaeval writers – but even penned entire texts in Classical Greek. Despite some fourteenth-century precursors such as Francesco Petrarca (1304–1374) or Coluccio Salutati (1331–1406), Renaissance humanism starts as a large scale phenomenon in the many small fifteenth-century Italian republics and was fuelled by the Greek émigrés. The patronage of the arts by Cosimo de' Medici (1389–1464) in Florence was especially important.[5] Among other things, he sponsored a Platonic academy led by Marsilio Ficino (1433–1499; see §4 below). Beginning in the second half of the fifteenth century, the movement moved across the Alps – early on it arrived in Vienna[6] – and took roots there in the sixteenth century, especially in Germany and the Netherlands. Cardinal Nicolaus Cusanus (1401–1464) was one of the early adopters; but, despite hailing from Kues (near Luxembourg), he characteristically spent most of his later life south of the Alps. This chapter begins with Renaissance humanism's approach to Latin (§2), then the most important currents of thought are introduced: hermetic neo-Platonism (§3), *magia naturalis* (§4), and mathematical theology (§5), leading to 'universal science' (§6). The next chapter treats the Scientific Revolution, which can be seen as a synthesis of the Aristotelianism discussed in the previous chapter and the Renaissance currents discussed here.

§2 Already in the later Middle Ages, people who practised good Latin tended to have studied at universities,[7] in contrast to the earlier Middle Ages, when basic Latin training was usually acquired at ecclesiastical grammar schools. Over the centuries it would seem that – although slowly and far from linearly – proficiency in Latin retreated to ever higher intellectual strata of society, which can be viewed in connection with the emergence of vernacular languages that drifted further and further from Latin, gradually replacing Latin in more and more facets of

5 On which see Hankins (1990).
6 Overfield (1984: 102–103).
7 See Korenjak (2016: 15).

life, and, finally, precipitating the end of Latin's predominance altogether (see chap. 14 below). Renaissance humanists were not content with university Latin and studied classical rhetoric; they became especially critical of the twelfth-century way of translating verbatim from Greek, which hurt Latin syntax and according to them produced *obscuritas*. Thus, the Renaissance translator Argyropoulos writes in his *Praefatio in librum Phisicorum* (Venetiis, 1496 edition), fol. 3v, about his new translation:

> *invenies, certo scio, faciliores nunc cognitu sententias omnes eius quas perobscuras olim interpretandi modus ille rudis reddebat.*
> 'you will, I do not doubt it, find all his [Aristotle's] thoughts, which that uncultivated way of translating rendered so obscurely in the past, to be of easier understanding.'

Some humanists even wrote treatises on how to translate from Greek. Leonardo Bruni, *De interpretatione,*[8] believed that Aristotle wrote in excellent Greek style and had been abused by mediaeval Latin translators.[9] The discussion of how to translate remained very much alive in the centuries to come. In 1531, Juan Luis Vives reached the other extreme, accusing Aristotle himself of *obscuritas*, worsened by the translators who 'did not leave it Greek and did not make it Latin', and by scholasticism (*De disciplinis*, ed. Vigliano, pp. 77–78):

> *Sed ut Aristotelis obscuritas multum nocuit artibus, sic horum in Aristotelem interpretationes artes omnes peruerterunt: non potuerunt recte Aristotelem exponere, et haec ipsa difficultas temeritatem atque impudentiam exacuebat, ut tanto magis auderet quisque pro interpretamento adferre quicquid in mentem uenisset, quo minus refelli ac confutari posset inter tantas tenebras: et (quemadmodum uulgo dicunt) perturbatus amnis quaestui erat piscantibus: [...] Versus est male ab imperitis, qui dum in latinum transferunt, nec latinum fecerunt nec reliquerunt graecum; [...] tractus ab expositore quo nunquam se Aristoteles uenturum potuit suspicari. Vt iam etiam uulgo inter eos non omnino, ut solent, inscite – Aristoteles dicatur habere nasum cereum, quem quilibet quo uelit flectat pro libito.*
> 'But as much as Aristotle's obscurity damaged the arts a lot, so the interpretations of Aristotle by these men perverted all arts: they could not expound Aristotle correctly, and this difficulty aggravated their rashness and impudence, so much so that the more anybody dared to bring forward whatever he had in mind as interpretation, the less he could be disproved or

8 *[L]ibros in greco plenos elegantie, plenos suavitatis, plenos inestimabilis cuiusdam decoris* ('In Greek the books are full of elegance, full of subtlety, full of a certain invaluable grace'; §2, ed. Viti, p. 74). Viti's edition also prints Bruni's interesting forewords; Kuhlmann (2002) re-evaluates Bruni's new approach.

9 In fact, the works of Aristotle we possess today were rather terse lecture notes; his works meant for wider circulation are, unfortunately, lost. On this topic in general, see Pym (1998).

> refuted within so much darkness. As people say: troubled rivers bring gain to fishermen.[10] [...] He was translated badly by inexperienced men, who while transferring the content into Latin, did not make it Latin but did not leave it Greek either. [...] Aristotle is drawn by the interpreter where he could never have expected to end up, so much so that Aristotle was publicly said among them [the scholastics] in a not at all ignorant way (as is otherwise their wont) to have a waxen nose that he turns whither he will.'[11]

Although there is no doubt that some late scholastic authors wrote complicated treatises with little actual content in what the humanists must have perceived as horrible Latin, it is on the other hand just as easy to hide a lack of understanding under a veil of classicist rhetoric. As in so many things humanist, Francesco Petrarca led the way. Trying to prove that Plato is to be preferred over Aristotle, he already inveighed against *insanum et clamosum scolasticorum vulgus* ('the insane and noisy rabble of the scholastics').[12] Petrarch preferred a rhetorical *Wissenschaftsmodell* to the then usual scholastic one (Kessler 1978: 198). In other words, he goes back to the classical Roman lack of interest in science in favour of oratory. A typical humanist rant against scholastic language and thought can be found in Lorenzo Valla's *Repastinatio dialecticae et philosophiae*. Among many other things, Valla claims that the suffix *-tas* is abused by scholastics: (4, ed. Zippel, p. 30):

> *Nulla nomina in 'itas' descendere a substantivis sed ab adiectivis, nec his omnibus.*
> *Quid, quod ab isto 'ens' faciunt 'entitas' (ut de hac quoque materia nunc disputem) qualia multa alia, ut a 'quid' 'quiditas', a 'per se' 'perseitas', ab 'hecce' 'hecceitas' et cetera, e barbarie quodam gurgustio prolata? Nam primum hec ab Aristotele non traduntur, deinde a substantivis deduci nequeunt: 'ens' autem et 'quid' substantiva sunt; postremo nec ab omnibus adiectivis, nisi ab iis que exeunt in 'us', que sunt secunde declinationis (quanquam nec ista omnia), aut in 'er' eiusdem declinationis, et que in 'is' tertie, et in quasdam alias litteras, non omnes tamen.*
> 'That no nouns in *-itas* can be formed from nouns, but only from adjectives and not even from all of them.
> Why, that they [the scholastics] derive *entitas* from the word *ens* – let me now enter upon this topic too – as well as many other cases such as *quiditas* from *quid*, *perseitas* from *per se*, *haecceitas* from *haecce*, and so on, acquired from some barbarian hovel. For, firstly Aristotle

10 This saying is not found in Walther (1963–1986). The idea seems to be that fish are more easily caught in the turbulent waters.

11 Vives attacked the Paris scholastics of his own day strongly in his *In pseudodialecticos* (ed. Fantazzi). More on Valla's, Vives's, and other prominent humanists' attacks against Aristotle and his followers in Rummel (1995: 153–192).

12 *De sui ipsius et multorum ignorantia* 4, ed. Buck, p. 112. Kessler (1978) evaluated Petrarch as a historian and philologist and reached mixed conclusions. Petrarch had no interest whatsoever for natural sciences and has to be seen mostly in a rhetorical, humanist context.

> does not use these terms, then they cannot be formed from nouns [in "proper" Latin], finally they cannot even be formed from all adjectives but only from those in *-us* (second declension) – although not even of all of them – and in *-er* (same declension), and those in *-is* (third declension), and some others, but not all.'

Later (5, p. 36) he claims that fine scholastic terminology is meaningless:

> *Inter 'essentiam' et 'esse' nihil interesse et item in ceteris, ut inter 'voluntatem' et ipsum 'velle'.*
> 'That there is no difference between *essentia* and *esse*, and similarly in other cases such as *voluntas* and *velle*.'

Both these points overshoot the target: it will have become obvious that a detailed terminology is fundamental for scientific thought, and there are even classical exceptions to his linguistic point (*necessitas* from *necesse*, *civitas* from *cives*). Nonetheless, such bold claims helped to make people more aware of their language, and considering to what parts of speech suffixes can be appended is an important linguistic achievement. Among authors like Valla, the prejudice of a dark middle age between the Roman orators and themselves began to be felt. For instance, Valla saw Isidore as *indoctorum arrogantissimus* ('the most arrogant of the uneducated').[13] Needless to say, these humanist polemicists did not make any significant scientific discoveries themselves – even less so than their much-admired Cicero (see chap. 8 §7). It was from these people that the idea of an unadulterated Latinity, allowing the use exclusively of what can be shown to be extant in Cicero, began; pupils of the humanist gymnasium had to put up with it as late as the twentieth century.[14] But some early humanists, such as Angelo Poliziano (1454–1494), already saw that a complete emulation of Cicero, prohibiting all words and expressions not found in him, was not a good idea. He points out in a letter to Paulo Cortesi (ed. Garin, p. 902):

> *Mihi certe quicumque tantum componunt ex imitatione, similes esse vel psittaco vel picae videntur, proferentibus, quae non intelligunt. Nihil ibi verum, nihil solidum, nihil efficax. Non exprimis, inquit aliquis, Ciceronem. Quid tum? non enim sum Cicero; me tamen, ut opinor, exprimo.*
> 'It seems to me that those who compose only through imitating are similar to parrots or magpies: they express what they do not understand. There is nothing true, nothing solid, nothing powerful in them. One says: "you do not express yourself like Cicero." And so? I am not Cicero; it seems to me that I should express myself as myself!'

13 *Elegantiae* II, ed. Garin, p. 602.
14 We will review some 'antibarbarus' literature from later times in chap. 14 §11 below.

New grammars (late mediaeval modist speculative grammar theory was among the main targets of the humanists)[15] and new dictionaries were necessary to teach the new language. The most successful, and at the same time an unusual and extreme one, was Nicolaus Perotti's *Cornucopiae* (1506). It started as a commentary on Martial but grew into a full dictionary of Classical Latin. A list at the beginning tells the reader where to find which word in the big tome. Thus, *scientia* is found in column 1019, part D, while commenting on Martial's *Epigramma* I.3 (modern numbering) *Argiletanas mavis habitare tabernas*:

> *Nescio autem ex ne & scio componitur. Scire autem proprie est rem ratione & per causam cognoscere a quo Scientia dicitur rerum quae sunt inmutabili ratione comprehensio. Cicero Ars enim eorum est quae sciuntur. Oratoris autem omnis actio opinionibus non scientia continetur.*[16] *Ponitur autem frequenter scio pro cognosco intelligo a quo fit Scisco inchoatiuum: & participium sciens: & Scienter aduerbium.*
> 'The word *nescio* is composed of *ne* and *scio*. *Scire* properly is to know something rationally and through its causes, which is why *scientia* is said to be the understanding by reason of things that are unchangeable. Cicero says: for art is of things that are known. But all actions of an orator depend on [his audience's] opinion, not on knowledge [*scientia*]. *Scio* is also often used instead of *cognosco* or *intelligo*; thus an inchoative form *scisco* is formed, besides a participle *sciens* and an adverb *scienter*.'

The examples and usages are exclusively classical: for instance, under *oratio* the author does not mention that the word also means 'prayer' in Christian Latin.[17] The sixteenth and seventeenth centuries will see more balanced dictionaries, beginning with Calepinus (used in chap. 2 §5 above).

Humanist Latin by no means supplanted scholastic Latin in the centuries following the humanist Renaissance. After sometimes rather bilious strife between humanist poets and scholastic scholars,[18] a kind of demarcation of competences largely prevailed: the former in rhetoric, speeches, poetry, and the like; the latter in universities and science.[19] The two registers, humanist and scholastic, of-

15 See Overfield (1984: 75–86).

16 Quotation from Cicero, *De oratore* II.7(30), ed. Kumaniecki, p. 115.

17 Further on the *Cornucopiae:* Furno (1995).

18 Some examples are studied by Overfield (1984: 120–142), e.g. 'many Germans resented the smug sense of superiority exuded by the Italians' (141).

19 Already Olschki pointed out: 'Es ist klar, dass man mit dem relativ beschränkten Sprach- und Stilschatz Ciceros nicht den ungeheuren Wissensschatz beherrschen konnte, den die Gelehrten der Renaissance aus den entferntesten Gebieten der Kultur- und Naturgeschichte zusammengetragen hatten' ('It is clear that with Cicero's relatively limited vocabulary and style, it was not possible to master the immense wealth of knowledge that the scholars of the Renaissance had gathered from the most remote areas of cultural and natural history'; 1922: 71). The same assessment is made by Stotz (1996–2004: I, §67.11 = vol. 1, pp. 166–167) and Korenjak (2016: 11).

ten coexisted much more closely than one tends to realise, as in Pico della Mirandola's (1463–1494) famous *Oratio de dignitate hominis*, written in very humanistic Latin in 1486 and intended as an introduction to his much longer catalogue of nine hundred theses in normal 'scholastic' Latin (*Conclusiones nongentae*).[20] Pico may have been more aware of the relativity of such language registers due to his familiarity with Greek and Hebrew. In a letter to Ermolao Barbaro, he points out (ed. Garin, p. 818):

> *quid prohibet hosce philosophos, quos nuncupatis barbaros, conspirasse in unam dicendi normam, apud eos non secus sanctam ac habeatur apud vos romana?*
> 'what forbids those philosophers whom you call barbarians having conspired to use a single linguistic norm as sacred to them as to you the Roman tongue?'

Pico goes on to quote the antique 'noble savage', the Scythian Anacharsis:

> Ἀνάχαρσις παρ' Ἀθηναίοις σολοικίζει, Ἀθηναῖοι δὲ παρὰ Σκύθαις.
> 'Anacharsis speaks badly for the Athenians, the Athenians for the Scythians.'

He concludes (pp. 820–822):

> *Scribat Lucretius de natura, de Deo, de providentia, scribat de eisdem ex nostris quispiam, scribat Ioannes Scotus et quidem carmine ut sit ineptior. Dicet Lucretius rerum principia atomos et vacuum, Deum corporeum, rerum nostrarum inscium, temere omnia fortuito occursu corpusculorum ferri, sed haec latine dicet eleganter. Dicet Ioannes quae natura constant, sua materia specieque constitui, esse Deum separatam mentem, cognoscentem omnia, omnibus consulentem. [...] At dicet insulse, ruditer, non latinis verbis. Quaeso, quis in dubium revocet, uter poeta melior, uter philosophus?*
> 'Let Lucretius write about nature, God, Providence; let someone of ours [a Christian] write about the same things, let us say Duns Scotus, and he is not so poetically minded. Lucretius will say that atoms and emptiness are the principles of things, God corporeal and not caring about our matters, that everything happens by chance collision of particles, but he says it in elegant Latin. Duns will say that what exists in nature is made up of matter and form, that God is a mind separate from it, who knows all, takes counsel about everything. [...] But he says it in a tasteless, rude manner, in words that are not Latin. I ask: who would doubt who is the better poet, who the better philosopher?'

Pico could say such things and get away with them among humanists, because he penned them in very rhetorical humanist Latin. In general, in later times the two approaches have to be seen rather as two different registers adapted for different uses than as exclusive types of 'good' and 'bad' Latin. Thus, although curricula shifted toward a greater importance of *studia humaniora* at German universities in

20 Editions: Garin; Biondi. More on Pico's 'double tongue' in Moss (2003: 67–70).

the later 1510s, scientific study, its sources and goals, hardly changed.[21] Humanism was a rhetorical, not a scientific movement. Indeed, Thorndike (1943) draws very negative conclusions about humanism's impact on science: he sees humanists as uniform and backward with their wish to imitate Roman classical times. Science was still predominantly done at Aristotelian universities, such as Padua (especially the natural sciences). Private academies and societies would only become important in science in the seventeenth century.[22] As Eugenio Garin puts it: 'Aristotelica, dunque, rimaneva, almeno per buona parte l'indagine scientifica, l'ossatura del sapere' ('Scientific investigation, therefore, remained Aristotelian, at least for the most part, the skeleton of knowledge'; 2009: 35).

In general, Mediaeval Latin is divided from Neo-Latin precisely on the grounds of a more classicist approach to language from the fifteenth century onward. In poetry, for instance, the difference is often striking. In contrast, the extent to which the humanist movement influenced scientific writing seems to depend quite a lot on the science in question. In less 'humanistic' sciences (so to speak) such as the natural sciences or medicine (see chap. 21 below), clear humanist linguistic influence is rare;[23] in some of them, a change of style around the sixteenth century can be observed, although not toward a humanist style but toward a Euclidean axiomatic approach, for example in mathematics and physics, but also in Spinoza's ethics.[24] In other sciences, a more pretentious, rhetorical style did come to be expected, for instance in philology or literary studies, indeed in the traditional human sciences. Philosophical scholasticism may be said to have become more conscious of its possible fallacies as a result of the attacks of the humanists. It was to remain important and was to produce a new flowering in Spanish neo-scholasticism (discussed in chap. 11 §7 above), which had, among other things, important contributions to make to the formation of international law. Incidentally, humanism and the human sciences bear a similar name by historical accident only,[25] but it has recently been pointed out that the humanist Poliziano can be seen as the ori-

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21 See Overfield (1984: 298–299).

22 On these see Biagioli (2002).

23 For some notes on the language of medicine, including exceptions to the above statement, especially Vesalius, see chap. 21 below. The interest in antique science that was significant in many fields would hardly seem typically humanist; it was already common among many mediaeval scholars. In law, for instance, authors such as Hugo Donellus (1527–1591) speak of 'legal humanism'. Their main point was to go back to the antique texts, disregarding mediaeval commentators.

24 Rummel (1995: 195) rightly speaks of the 'third option' besides scholasticism and humanism.

25 Compare German *Humanismus* vs *Geisteswissenschaft*. Indeed, the former's meaning is a recent acquisition, coined by Niethammer (1808).

ginator of a special kind of humanist science.[26] He proposes in his *Panepistemon* a new classification of the sciences into *speculativa* (approximately natural sciences), *practica* (approximately *artes mechanicae*), and *rationalis* (encompassing *historia ad fidem*, distinguished from *historia fabulosa*, which is not scientific; dialectic, rhetoric, and poetry). This adds the scientific study of history to the usual *trivium*, but we have seen (chap. 9 §1) that a similar approach can already be traced in Augustine.

Sarton (1929: 80) had a point when he called Renaissance humanists 'sophists' with few exceptions. But even if humanism as a rhetorical movement had little impact on science, the renewed interest in Antiquity also led some humanists to seek out new ways in scientific inquiry. It will become apparent that the Renaissance Platonist movement did provide some new methodological impulses to science.

§3 The Renaissance had a clear preference for Plato over Aristotle. Renaissance scholars meant to reintroduce what was lost from Antiquity, such as Platonism, but this grew into something quite new. In the case of Renaissance Platonism, antique neo-Platonism grew into hermetic neo-Platonism with a penchant toward pantheism and a special interest in magic.[27] The priest Marsilio Ficino (1433–1499) translated all the extant Platonic dialogues into Latin for the first time at Lorenzo de' Medici's Platonic academy in Florence; he also translated many neo-Platonic works, such as Plotinus' *Enneads* and the *Corpus Hermeticum*.[28] He delved so far into neo-Platonist occultism that he had to write an *Apologia* justifying his interests.[29] The *Corpus Hermeticum* in particular came to enjoy huge prestige as *prisca sapientia* (a term dear to Ficino) and an Egyptian precursor of ancient Greek learning, especially at Italian Renaissance academies; this lasted at least until the philologist Isaac Casaubon was able to date this 'ancient' wisdom to Late Antiquity in 1614. The *Corpus Hermeticum*'s main theme is the unity of all things that the hermeticist should find, especially his own with God. The result is quite far from science as we understand it; Sarton (1929: 79) would speak of a 'superficial mixture of ideas too vague to be of real value'. Neo-Platonism, which had already been largely incorporated into the thinking of the Church Fathers in a 'purified' form (i.e. minus its all too 'pagan' and 'superstitious' constituents) and thus heavily influenced the Middle Ages and scholasticism, returned now in its unadulterated late antique form – including the traits that the Church

26 Edelheit (2015).
27 The seminal study on this is Yates (1964).
28 Greek text ed. Nock & Festugière.
29 Details in Thorndike (1923–1958: 4:562).

Fathers had found unacceptable. Interestingly, these were mostly non-scientific ones, as we would say today (using e.g. the criteria in part 1): theurgy, demonology, magic, secrecy (lack of sharing results with the uninitiated), or number mysticism. Thus, Renaissance science with its turn to 'Platonism' (through neo-Platonism) was rather a step back in terms of scientific testability and transparency. We can quote a later, but very characteristic author: Giordano Bruno. He is notable for his philosophical poems (Francofurti, 1591) written in clear imitation of Lucretius. *De monade, numero et figura* studies the first ten numbers as metaphysical entities and their magical and philosophical meanings in very obscure and often purposefully ambiguous language, of which the following sentence describing the circle can serve as an example (*De monade, numero et figura* 2, lines 4–14, ed. Fiorentino, vol. 1.2, p. 335):

Hoc de fonte fluunt primoque parente, figurae
Clarandaeque forum ipsius iustumque tribunal
Conquirunt, facie inque sua spectantur adauctae,
In faciemque suam degliscunt omnia tandem:
Illius ut crescit surgens in imagine horizon
Amplius a nostris se quando sensibus effert,
Illius ut formam capiunt attrita recessu
Corpora ad obtutum, quando momenta perire
Cuspidis expertum est, laterum discrimina vultus
Amittunt rerum, in speciem cita principiorum,
Quo amplius in nihilum ad oculos solvenda fatiscunt.

'From this source and first ancestor [i.e. the circle] they [i.e. mathematical shapes] flow forth, the figures that are to be explained search it out as its marketplace and its just tribunal. When increased, they are seen in its surface; toward its surface they all un-grow[30] at length. The horizon grows in its image as it widens further when it removes itself from our senses. Apparently, worn-off bodies take something like its form in departure, when it experienced the perishing of the thrust of the spear,[31] and the looks of things lose the difference of their sides, then cite them to the realm of ideas where visible things decay the more into nothingness.'

The poems are in general very hard to understand: often it is hard to tell whether the author is speaking about geometric constructions or about metaphysical entities: in fact, it would seem that he usually intends both. The vocabulary is relatively normal; the obscurity comes rather from the often ambiguous syntactic nexuses and the precise meaning of the often poetically circumscribed terms. Secrecy was certainly intended. Bruno also wrote more accessible works in Italian.

30 *Deglisco* is a very uncommon word, not found in dictionaries.
31 Von Samsonow et al. (1991: 226–227) believe this to be a *chiffre* for a geometric method.

§4 One way in which the new Renaissance outlook did profit science was through its stress on experimentalism, which went under the heading of *magia naturalis*.[32] Arabic sources already differentiated between 'natural' and demonic magic,[33] only the first of which is licit. The Latins took this over; the Latin term is used as generally known since at least William of Auvergne (d. 1249).[34] Giambattista della Porta's (1535?–1615) huge encyclopaedia, *Magia naturalis* (1558), shows the wide range of phenomena that could be subsumed under this heading: a lot of medicine, magnetism, poisons, witches, invisible writing, and much more. This natural magic is eulogised by Cornelius Agrippa of Nettesheim (1486–1535) as (*De occulta philosophia* I.2, ed. Compagni, p. 86):

> *Magica facultas, potestatis plurimae compos, altissimis plena mysteriis, profundissimam rerum secretissimarum contemplationem, naturam, potentiam, qualitatem, substantiam et virtutem totiusque naturae cognitionem complectitur et quomodo res inter se differunt et quomodo conveniunt nos instruit, hinc mirabiles effectus suos producens, uniendo virtutes rerum per applicationem earum ad invicem et ad sua passa congruentia, inferiora superiorum dotibus ac virtutibus passim copulans atque maritans: haec perfectissima summaque scientia, haec altior sanctiorque philosophia, haec denique totius nobilissimae philosophiae absoluta consummatio.*
> 'The magic faculty, compounded of most powers, full of highest mysteries, comprises the most profound contemplation of secret things, nature, potency, quality, substance and virtue, and the knowledge of all nature. It instructs us how things differ among one another and how they come together in order to produce their miraculous effects by unifying the virtues of things by applying them to one another and to their congruent passive sides, by here and there coupling and marrying the lower things to the gifts and virtues of the upper [heavenly]. This is the most perfect and highest science, this is the higher and holier philosophy, this, finally, is the absolute consummation of the most noble philosophy.'

This passage is quite typical in many ways: the complicated, hymnic language, the emphasis on mystery but also the lack of interest in scientific step-by-step explanations. Other authors were less cautious and did study illicit, demonic magic as well. Authors who engaged in it often fared badly: Giordano Bruno was burned at the stake for heresy in 1600; John Dee (1527–1608/1609) had to face a life of hardship. Not such extreme adepts, but rather experimentally minded scientists who coupled magical 'virtues' and higher and lower influences, were to have last-

32 On which see Zambelli (2007). The form *magica* is also used with the same meaning.
33 The latter is forbidden as sorcery in Islam (Quran, *Sura* 2.102). The Arabic roots of *magia naturalis* and their effects on the Latin world merit a profounder study than Saif (2015).
34 See Thorndike (1923–1958: 3:346), quoting *De universo* I.1.43, 1674 edition, vol. 1, p. 648: *in ea parte naturalis scientiae, quae vocatur magica naturalis* ('in that part of natural science that is called natural magic').

ing influence. Indeed, one of the main points of Thorndike's magnum opus (1923–1958) was to show the kinship between such magic and the rise of experimental science; a point that has today become a commonplace. In this split of *magia* into magic proper (*magia ritualis vel daemonica*) and *magia naturalis*, which becomes a part of *scientia,* the formative rôle of the Church should not be overlooked: it was the Church that made *magia* refrain from accepting demonic (unscientific) powers as 'mechanisms' – the same sound guiding influence it had already exercised in Late Antiquity on neo-Platonism. On the other hand, licit *magia naturalis*'s experimental and mechanistic tendencies greatly benefited the development of natural experimental science.

Apart from authors on *magia naturalis*, a new type of technician and practical scientist becomes more common in the fourteenth and fifteenth century; for the first time, some of these practitioners did not hail from Latinate society. Leonardo da Vinci (1452–1519), for instance, was self-taught in Latin, and his theoretical works did not find as great a resonance as his famous art. Others are still understudied, such as the Venetian engineer Giovanni Fontana (ca. 1395–ca. 1455);[35] his works on war machines, mnemotechnics, and clocks still exist only in manuscript form, but a work of his on machines has recently been edited (*Liber instrumentorum iconographicus*, ed. Kranz). He also wrote an encyclopaedia of natural philosophy that was printed in 1544. Niccolò Tartaglia wrote a treatise on ballistics in Italian (*La nova scientia*, 1537). Natural scientists of the following period were to profit from their new devices and discoveries. Galileo (chap. 13 §4) was to fit well into this type of practically minded scientist and engineer.

A brief look at the language used by two important authors will now be taken. Hieronymus Cardanus (1501–1576) stood between different worlds: he was a scientist in the new spirit (see next chapter) and was interested in natural magic, Lullian combinatorics, and new scientific devices; his style is sometimes quite in the vein of the humanism of his time, but his many compendious works look rather scholastic in nature. There are some 130 printed works of his; they treat problems in mathematics, physics, medicine, astrology, philosophy, religion, and music. His main contributions were mathematical and medical. His mathematical main work is called the *Ars magna* (Norimbergae, 1545), echoing the title of Lullus' main work (see §5 below). This work presents for the first time general solutions to polynomial equations of degrees 3 and 4, although these formulas were not discovered by Cardano himself. His large, encyclopaedic compendium *De subtilitate* treats 'subtlety' in twenty-one books (1st ed., Norimbergae, 1551). He aims to ex-

35 See Clagett (1976) on his life and works.

plain difficult and refined things in nature, man, the senses, the soul, science, demonology, theology; the epilogue adds (Basileae, 1554 edition, p. 560): *quaedam ob raritatem, quaedam ob difficultatem adiecimus* ('we added some things because of their rarity, some because of their difficulty'). His goal is explained thus (I.1, ed. Nenci, p. 53):[36]

> *Propositum nostri negocii in hoc opere est, de subtilitate tractare. Est autem subtilitas ratio quaedam, qua sensibilia a sensibus, intelligibilia ab intellectu, difficile comprehenduntur. [...] Idque solum apertum et facile videri potest, quod in unaquaque disciplina est obscurissimum. [...] Cum enim scribentes in quatuor laborent generibus, rerum obscuritate, incertorum dubitatione, causarum inventione, rectaque earum explicatione, omnia haec hoc in libro cumulatius habentur. [...] Quaedam etiam cum desierint, aut nuper sint inventa, nominibus aut carent, aut nomina rebus ipsis. Porro nomina invenire novis rebus, et senescente lingua, difficillimum est. [...] Constat ergo subtilitas in tribus, substantiis, accidentibus, ac repraesentationibus.*
> 'The purpose of our work is to treat "subtlety". Subtlety is an approach by which sensible things are understood by the senses with difficulty, intelligible things by the intellect. [...] And it alone is capable of making openly and easily visible what is most difficult in each discipline. [...] Now, as those who write struggle with four problems: obscurity of things, doubting of uncertain things, finding of causes, their correct explanation: all of these are contained in this one book together. [...] Some things that are missing were either recently discovered, or lack names, or the names lack things. But it is very hard to invent names for new things in a language that is growing old. [...] Thus, "subtlety" consists of three spheres: substances, accidents, and representations.'

The author thus believes that explaining difficult things in all sciences in one book will help to make them plainer. He is also an early scientific voice perceiving Latin as growing too old for scientific use. The book contains many geometric figures and some sketches of 'subtle' devices.[37] Julius Caesar Scaliger (1484–1558) wrote a 1,128-page 'review' (*Exoticarum,* first published 1557) of the work, disagreeing with some things and elaborating on others, which shows a spirit of scientific discussion.

§5 A related undercurrent with a long past but becoming influential only during Renaissance times is mathematical theology of a 'Pythagorean' kind. Its kinship to hermeticism and neo-Platonism is apparent – Proclus had already tried to mathematicise theology in his *Elementa theologica* – but its line of development leads elsewhere. Authors of this kind had a tendency to coin unusual vocabulary

36 This is a modern edition of books I–VII; see also the edition project at http://www.cardano.unimi.it.
37 The approach to natural science is analysed by Schütze (2000).

for their unusual thoughts. In fact, this – as we might call it – ‘lower’ neo-Platonism had already reached some individuals before Ficino’s translations, presumably through Arabic intermediaries or direct contact. An influx of Christianised Qabalistics already arose in some authors in the thirteenth century. This kind of thought typically sought correspondences or ‘sympathies’ between different levels of reality. Examples are the Byzantine demonologist Michael Psellos (1017/1018–ca. 1078), who had direct access to the Greek sources, the eschatologist Joachim of Fiore (ca. 1135–1202) in his *Liber figurarum* (ed. Tonelli),[38] the Catalan missionary Raimundus Lullus (ca. 1232–1316), or alchemists such as John of Rupescissa (1310–ca. 1370).

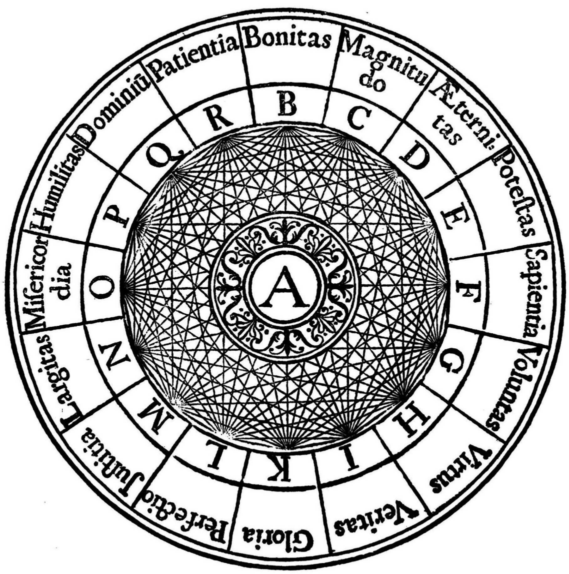

Fig. 20: *Figura A* from Lull’s *Art* (Moguntina edition, vol. 1, after p. 432).

Lullus worked on his *ars lulliana* for much of his life, a combinatoric system that he believed would be able to reform the sciences, especially the science of theology, and become their common foundation. In various forms of movable figures with epithets of God (one of them is depicted in fig. 20), he believed he was able to form the basis of a ‘scientific’ theology that would prove the Trinity and the Incar-

38 On this topic, see Guerrini (2016).

nation of Christ to non-Christians. His system seems to have been inspired by Qabalah and mystic Islam. Lull's *ars* is apparently meant to be able to classify all strata of being, but it does not work purely mechanically;[39] the name *ars* (not *scientia*) may have been chosen in order to stress its practical aspects of bringing the *artista* toward God. Leibniz was to be impressed by this art and would develop it further, although in a mathematical not a theological way, into the science of combinatorics. Its details remain – despite repeated new attempts to explain it by its author – rather obscure. It would seem that the obvious closeness of mystic currents in all three Abrahamitic religions that Lullus had apparently noted stems from their common neo-Platonist ingredients. They also form the basis of Lullus' system. This system would fail to qualify as scientific according to our criteria, but this important precursor of Renaissance Platonism used a very special language that is worth noting in this context. He coined terms that might be called hyper-scholasticisms, such as *unificentia, bonificentia, aeternificentia*,[40] and constructed a fully fledged system of derivations in groups of divine attributes. Thus, *bonitas* becomes the set of *bonificativus, bonificabilis,* and *bonificare:*[41] that through which *bonitas* happens, that which can receive it, and the act of bestowing it. Thus, the typically scholastic suffixes *-ivus* and *-bilis* can be used freely to build up a linguistic system mirroring Lullus' conception of how things are. This may be the boldest mediaeval attempt at Latin language engineering. The following example illustrates both his language and his main idea (*Ars generalis ultima* 1, ed. Madre, *ROL* 14, pp. 5–6):

> *Quoniam intellectus humanus est ualde plus in opinione, quam in scientia constitutus, ex eo quia quaelibet scientia habet sua principia propria, et diuersa a principiis aliarum scientiarum, idcirco requirit et appetit intellectus, quod sit una scientia generalis ad omnes scientias. Et hoc cum suis principiis generalibus, in quibus principia aliarum scientiarum particularium sint implicita et contenta, sicut particulare in uniuersali. Ratio huius est, ut cum ipsis principiis alia principia subalternata sint et ordinata, et etiam regulata, ut intellectus in ipsis scientiis quiescat per uerum intelligere, et ab opinionibus erroneis sit remotus et prolongatus. Per hanc quidem scientiam possunt aliae scientiae faciliter acquiri.*
> 'As the human intellect is much more grounded in opinion than in science, due to the fact that every science has its own principles, differing from those of the other sciences, therefore the intellect requires and desires one science general to all other sciences. And this science ought to have its own general principles, in whose principles those of the other particular sciences be implicit and contained, as particulars are contained in universals. The reason for

39 He says: *absque ratione artista non potest bene uti ista arte (*'without reason the artist cannot use this art well'; *Ars generalis ultima* 13, ed. Madre, *ROL* 14, p. 524). Platzek (1962) is a good introduction to this difficult author.

40 *Liber de scientia perfecta* dist. 1, ed. Stöhr, *ROL* 1, vol. 1, pp. 224–225.

41 *Ars generalis ultima* IV.3, ed. Madre, *ROL* 14, p. 31.

> this is that by these principles others will be subordinate to them and be put in line and also be ruled, so that the intellect will find peace in these sciences understanding the truth and that it can be removed and separated from wrong opinions. By means of this [general] science the other sciences can then easily be acquired.'

It may be important in this context that Lullus was a layman, an outsider among university people, who came to scholarly writing only after undergoing a mystical experience. What Lullus may have groped his way toward is the idea that formalisation (in the form of mathematics as well as language engineering) can indeed be a general foundation for all sciences. There was serious opposition to Lullus' innovations in university circles, and even the Inquisition took an interest in him.

Another author in this tradition is Cardinal Nicolaus Cusanus (1401–1464), who had read Lullus and also coined unusual words, although he did not create a system from them. Often they are also attempts to name the unnameable (God), such as his *possest* (of God being the *coincidentia* of *actus* and *potentia*, *posse* and *esse*), or his referring to God as *tricausalis*. A matter of questionable Greek is his *trialogus*, a dialogue between three people.[42] Other authors who continued to spin such ideas further include magicians such as Giordano Bruno and John Dee.

§6 Similar hermeticist neo-Platonist currents[43] can still pop up among scientific disciplines today – as in Rudolf Steiner's (1861–1925) 'spiritual science', Carl Gustav Jung's (1875–1961) depth psychology, or Fritjof Capra's (1939–) Taoist Physics – usually controversial and often spurned by scientists in the fields in question. What unites these authors can be described as introspection, mysticism, esotericism, and holistic approaches, all of which have been alien to university scholarship and science, whose methodology stayed largely Aristotelian through the Renaissance and still is so today.[44] Another point that unites at least some of the authors mentioned is their dabbling or even outright failures in generally acknowledged science: Lullus was convinced that his *ars nova* could revolutionise all sciences, and Cusanus believed he had squared the circle.[45] This universalist

42 διάλογος is, of course, derived from δια-, not δύο. But Cusanus did not invent the word: Wycliffe had already used it as a work title: *Trialogus*, ed. Lahey; see Werner (1999).
43 An important tool for studying these currents is Hanegraaff (2006).
44 Kullmann (1974, 1998) shows the many links between modern science and Aristotelian methods.
45 See Uebinger (1895: esp. 403–414). Regiomontanus, *De triangulis*, proved that Cusanus' constructions were wrong.

approach continued to flourish in the age of the Scientific Revolution as a kind of science which tried to produce a synthesis of the Platonic Renaissance science and the 'new' science (treated in the next chapter); among these authors, Kircher believed he had deciphered the Egyptian hieroglyphs. This approach typically made use of the Latin language, of tables and figures and systems of characters and signs of all kinds, though less of mathematical ones. These authors mix 'Wissenschaftlichkeit und stilistische Höhenflüge' ('scientificity and stylistic flights of fancy'; Korenjak 2016: 246). Some among them would become part of the scientific mainstream, such as Copernicus, whose motivation for putting the Sun at the centre of the universe was at least in part a kind of mystical Sun-theology,[46] or the hermeticist Kepler (on these authors, see chap. 13).[47]

On the whole, the Renaissance movement did change the outlook on many things, but (Thorndike 1923–1958: 4:4)

> much of all this was a somewhat superficial phenomenon and not so extensive as it appeared on the surface. The scholastic method was kept up at numerous universities. Medieval Latin and Arabic authors continued to pour from the printing press.

The authors of this mystic-holistic and Platonic 'science' were much less numerous than the countless 'Aristotelians' at the universities since the thirteenth century. They can be arranged in a web of dependencies in a way that the authors from before and during the Scientific Revolution studied in the next chapter could not. This provides a hint to the fact that this Platonic scientific 'underground' movement was of a much more limited scope than the Aristotelian 'mainstream' science, although, of course, the two movements were linked. The authors at the bottom right in figure 21 were, in fact, also important exponents of the Scientific Revolution. Experimentalism and *magia naturalis* and a new return to Greek natural science were major ingredients in the Scientific Revolution discussed in the next chapter. We might consider having the period of Renaissance science end in AD 1543, the *annus mirabilis* (Sarton 1929: 86) in which several groundbreaking works for science were published.

46 e.g. the hymnic formulation in *De revolutionibus* I.10 quoted in chap. 13 §4 below.
47 e.g. Kepler's *Harmonices mundi* (Lincii, 1619) is of a hermeticist nature.

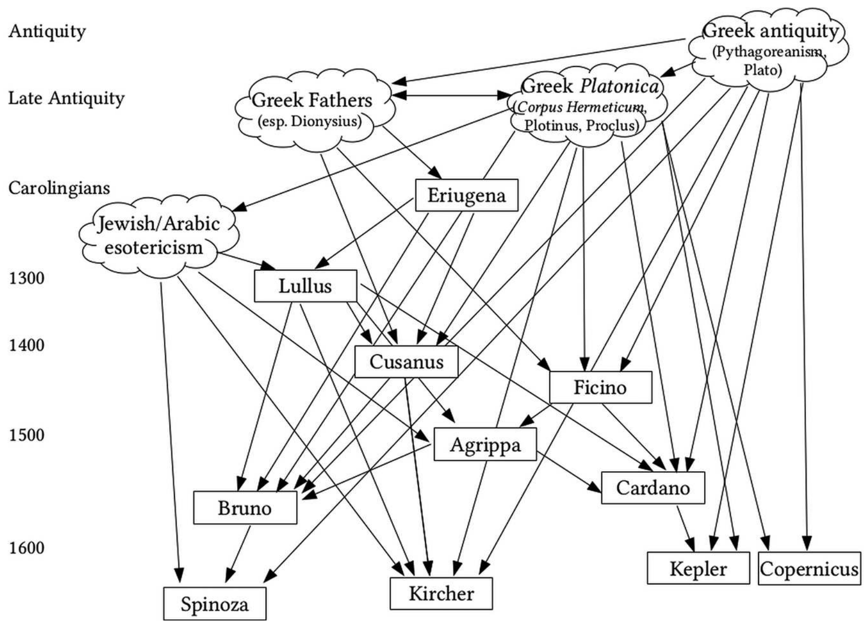

Fig. 21: Tentative web of influences among some important hermetic-Platonist authors.

Relation to criteria for science

§7 Despite the Renaissance's importance as a literary movement, it failed to alter the sciences to the same depth. Especially in the natural sciences, universities kept using scholastic methods and language; indeed, it will be seen below (chap. 18) that the language employed changed much less dramatically in the fifteenth century than it had with the advent of scholasticism in the thirteenth. It might be argued that the new forms of Renaissance Platonism stimulated mathematical approaches and *magia naturalis* experimental ones, thus paving the way for the Scientific Revolution treated in the next chapter. This is true to some extent, but mathematics progressed to its significant advances in the sixteenth century largely in traditional settings; indeed, a chain of important precursors from the twelfth to the fifteenth century can easily be named.[48] Precursors for the experimental method among the 'magicians' of the pre-humanist centuries can also be found abundantly, as Thorndike's monumental work (1923–1958) shows.

48 The fourteenth-century Oxford calculators were encountered above (chap. 11 §5); for arithmetic, some more texts will be met below (chap. 20 §2).

While rhetorically minded Renaissance humanism had its influence on some concomitants of science but was not a scientific movement at all, the other current we have described, Platonic Renaissance hermeticism, can be said to have had a systematic method (I) and to have built a coherent system (IV), but it was one that focused too much on the greater patterns only (II) and largely lacked testability (III). It did not 'walk' (as Galen put it). A larger community was certainly active at the Aristotelian universities than at the Renaissance private academies (V). As already stressed, some authors moved in both worlds, some also used both kinds of Latin (humanist and scholastic) for different purposes, and in some authors mathematical formalisation advanced significantly – but these are the very authors usually included in the Scientific Revolution to be studied in the next chapter. Thus, the quotation from Sarton at the beginning of this chapter is largely confirmed: the Renaissance was not so much one of science, but some of its new ideas – especially mathematical and experimental *magia naturalis* – would still bear fruit in the Scientific Revolution.

13 New science in the old tongue

> Auch Ansätze zur Mathematisierung in pythagoräischer Tradition haben wir bereits kennengelernt, so daß die Annahme, wonach die naturwissenschaftliche Methodologie in der Neuzeit blitzartig und wie eine neue Offenbarung der Menschen einsetzt, heute fragwürdig erscheint.
> 'We have also encountered approaches to mathematisation in the Pythagorean tradition, so that the assumption that scientific methodology in modern times begins in a flash and like a new revelation of mankind seems questionable today.'
>
> Mainzer (1988: 69)

§1 Reference is often made to a Scientific Revolution in the later sixteenth and seventeenth centuries that is seen as the foundations of modern science or even the beginning of 'true' science in general.[1] The concept of such a revolution goes back to Alexandre Koyré (1939), who tried to show that the focus of natural science changed radically in this time, leading to modern science – that, using later Kuhnian terminology, a new paradigm arose. Koyré later claimed that Galileo's quantitative approach to science was completely new, and that, therefore, in a certain sense science proper begins only in the seventeenth century.[2] Lloyd reviews this thesis in detail and refutes it, pointing out that, indeed, in some cases the Platonic 'search for exactness led not to Koyré's "universe of precision" but to spurious quantifications and ad hoc numerological elaborations'.[3] It would seem that this 'revolution' in natural science was not so much based on new approaches or theories but more on a more strictly empirical approach and significant advances in mathematics that could now be applied to many fields. It was also a very slow revolution. Its roots are much older than the sixteenth century, mainly (i) the twelfth-century translations (chap. 10 above), (ii) the mediaeval universities (chap. 11), and (iii) the rise of the scholastic theologian/natural philosopher, as rightly pointed out by Grant.[4] Some have argued that the preconditions for modern science lay in late mediaeval changes in society, especially economic ones: in a

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1 See the useful encyclopaedia of Applebaum (2000). Shapin (1996) is an introduction to the topic. Wootton (2015), for instance, argues for the 'true' beginning of science only in this period.
2 In Koyré (1968: 89–113). Koyré admitted an exception in the study of the supra-lunar world in Antiquity, which did seek precision.
3 Lloyd (1987: 257), speaking of Hippocratic texts in Antiquity. He concludes (271) that 'no simple hypothesis to the effect that the ancients totally failed to make use of measurement will do'. He adduces counterexamples for geophysics, astronomy, harmonics, and optics.
4 Grant (1996: 171–176). 'These three pre-conditions just discussed [...] laid a foundation for the emergence of modern science because they provided an environment that was conducive to the study of science' (176). Grant also rightly stresses the importance of the Mediaeval Latin scientific vocabulary for the Scientific Revolution (198).

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more general tendency to measure things precisely and a greater monetarisation of society in the fourteenth century emerging, again, from scholastic philosophy.[5] Some have stressed the Protestant view of science's utility to improve human life and society, although this goal is quite absent in many of the Scientific Revolution's main works and many were written by Catholics.[6] It is striking that many of the important scientists of the revolution worked outside traditional universities, or at least were in contact with artisans and craftsmen who could devise new tools useful in many scientific branches.[7] In other words, a rise of empiricism led to many of the new discoveries. This chapter reviews the discussion, now over half a century old, of whether a distinct epoch of revolutionary science from the mid-sixteenth century to the end of the seventeenth century is warranted (§3) and then more specifically tries to shed light on what kind of language was used by these scientists (§5). Some data on the people and works involved in general (§2) and some prominent examples (§4) are also presented. Finally (§6), two of the most successful scientific authors of their time are compared (Kircher and Newton).

§2 The important novelties that revolutionised many sciences are certainly quite far apart both in time and space, as the following list of some of the seminal works in the new spirit illustrates. This chronological list contains works up to and including Newton, and only those first published in Latin. The next chapter will list some more seminal works, now in the vernacular, mostly after Newton (chap. 14 §3). In the course of roughly 150 years, many sciences changed fundamentally, but not all of them evolved in the same directions, as becomes especially evident from including non-natural sciences in the list. Most of these works are rightly famous and do not require a detailed description.

- Botany: Leonhart Fuchs, *De historia stirpium* (Basileae, 1542).
- Heliocentric astronomy: Nicolaus Copernicus, *De revolutionibus orbium coelestium* (Norimbergae, 1543), but influential only later, mainly through Johannes Kepler (1571–1630).[8]

5 Thus Kaye (1998).

6 Tambiah (1990: 12–13, based on Weber) sees this Scientific Revolution as a product of Puritan Anglicanism with its emphasis on utilitarianism, empiricism, and the improvement of nature, which – though an interesting observation of commonalities – goes much too far: many of the revolutionised sciences in the list below are not at all utilitarian or trying to improve nature, not even all of them are empirical, and few of the authors are Anglican. The new religious competition may, however, have helped to allow various kinds of novelty to gain ground.

7 This aspect is explored by Long (2011).

8 But see Gingerich (2002, 2004) for exceptions.

- Anatomy using dissection: Andreas Vesalius, *De humani corporis fabrica* (Basileae, [1543]).
- Mining and geology: Georg Agricola, *De natura fossilium* (Basileae, 1546) and *De re metallica* (Basileae, 1566).
- Zoology: Conrad Gesner, *Historia animalium*, 5 vols (Tiguri, 1551–1587).
- Textual criticism: Francesco Robortello, *De arte sive ratione corrigendi antiquorum libros disputatio* (Patavii, 1557).
- Historical source criticism: Jean Bodin, *Methodus ad facilem historiarum cognitionem* (Parisii, 1566).
- Establishing change in the heavens (supernovae): Tycho Brahe, *De nova et nullius aevi memoria prius visa stella* (Hafniae, 1572).
- Symbolic mathematical notation: Franciscus Vieta, *In artem analyticen isagoge* (Turonis, 1591).
- Magnetism, electricity, and forces: William Gilbert, *De magnete* (Londini, 1600) and *De mundo nostro sublunari philosophia nova* (posthumous, Amstelodami, 1651).
- Chronography: Joseph Justus Scaliger, *De emendatione temporum* (Lutetiae, 1583) and *Thesaurus temporum* (Lugduni Batavorum, 1606).
- Mathematical astronomy: Johannes Kepler, *Astronomia nova* ([Heidelberg], 1609), and Galileo Galilei, *Sidereus nuncius* (Venetiis, 1610).[9]
- Empiricist methodology: Francis Bacon, *Novum organon* (Lugduni Batavorum, 1620).
- Blood circulation: William Harvey, *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (Francofurti, 1628).
- Foundation of international law: Hugo Grotius, *De iure belli ac pacis* (Parisiis, 1625).
- Analytical geometry: René Descartes, *Geometria* (Lugduni Batavorum, 1649).[10]
- Sinology: Athanasius Kircher, *China illustrata* (Amstelodami, 1667).
- Stratification (geology): Nicolaus Steno, *De solido intra solidum naturaliter contento* (Florentiae, 1669).
- Ethics in mathematical form: Benedict Spinoza, *Ethica ordine geometrico demonstrata* ([Amsterdam], 1677).
- Scientific study of charters: Jean Mabillon, *De re diplomatica*, 2 vols (Luteciae Parisiorum, 1681–1704).

9 Galileo also published important works in the vernacular. Kepler complains about this as he could not read Italian (see Korenjak 2016: 237).

10 Descartes published this booklet in French in 1631 (as an appendix to his *Discours de la méthode*), but it became widely read only in the commented Latin translation by Frans van Schooten.

- Differential calculus: Gottfried Wilhelm Leibniz, *Nova methodus pro maximis et minimis*, in *Acta eruditorum* (Lipsiae, 1684); also developed independently by Newton.
- Gravitation: Isaac Newton, *Philosophiae naturalis principia mathematica* (Londini, 1687).

We end the list (which has no pretensions to completeness) with Newton, whose first main work was published in Latin, his second (the 1704 *Opticks*)[11] in English. Some of the listed authors also wrote in their vernacular languages, but Latin is still clearly the standard language, a situation that changes only in the eighteenth century. Geographically, it is striking that these works were first printed all over central and north-west Europe, but with a large proportion in Germanic countries, some also in France and Italy, largely corresponding to the former Carolingian Empire, apparently then still the centre of European innovation.[12]

If this period should be seen as the 'Scientific Revolution', it was one that not only encompassed the natural sciences (chap. 14 §3). As the list above shows, there were many groundbreaking publications in human and other sciences as well; a similar list for philosophy proper would also contain many groundbreaking works in the same timeframe. Thus, we might well suspect that the later sixteenth and the seventeenth centuries were in general favourable for new methodological approaches in many parts of intellectual life. Indeed, several of the quoted works use the adjective *novus* in their title, showing that there was a consciousness of wanting to do something new.[13] Another uniting factor in the above works is that their results and methods go beyond and often even against Aristotle. Many lost faith in the Aristotelian *causa finalis* and tried to give mechanistic explanations of events. Nonetheless, the general approach to science was still very Aristotelian; the changes (such as stronger mathematisation) happened where new tools had become available that earlier Aristotelians lacked.

Again, translations from Greek – either new ones or now widely available ones through print – played a vital rôle for some of these new approaches (although less

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11 But within two years, this was also published in Latin as *Optice, sive de reflexionibus, refractionibus, inflexionibus et coloribus lucis libri tres* (Londini, 1706).

12 The importance of Carolingian times for the later European *Sonderweg* is developed by Mitterauer (2004).

13 Many authors noted this. Campanella writes: *saeculum nostrum plus historiae habet in annis centum, quam mundus totus in 4000 pluresque libri editi sunt in hoc centenario, quam in 5000* ('Our century has seen more history in a hundred years than the entire world in four thousand, and more books were published in this century than in five thousand'; *Civitas solis*, ed. Tornitore, p. 136). He then emphasises the importance of the printing press.

strongly so than in the twelfth century). In 1482 Euclid’s *Elementa* were printed in Latin; in 1544 Archimedes, *Opera omnia* (Greek and Latin, the translation from ca. 1450); in 1575 Diophantus, *Arithmetica;* in 1588 Pappus of Alexandria, *Synagoge*. But some of these works important for the ‘New Science’ had already been translated in the twelfth century without much effect (such as those by Archimedes).[14] In the sixteenth century, all these works became very important for the further development of mathematics and subsequently of mathematical physics. Some of the new approaches are well exemplified by Galileo: a strong belief that mathematics is a better language for understanding nature than any other (a conviction that might be called Pythagorean-Platonist), its application in physics and astronomy (following Archimedes), but also the end of the learned disdain for technical apparatuses and manual work,[15] and perhaps also a heightened awareness of the importance of scientific methodology (*methodus* also becomes an important word). However, mathematics is not the only kind of novelty that would make up even the revolution in the natural sciences.

§3 Whether all these novelties together justify the term ‘Scientific Revolution’ is much debated, and although there is these days a tendency against it,[16] there are some rather strong arguments in favour of it.[17] It remains a fact that most sciences changed profoundly in these roughly 150 years, often more than in the entire time since their (mostly) Greek beginnings. The great amount of new things in society may have been the major trigger for change leading to a new inquisitive spirit and pride in novelty. On the other hand, new and old went hand-in-hand, and we must refrain from picking out *ex post* those authors (or works) that fit in best with what will later become the normal way of practising science (i.e. a combination of mathematics and empiricity) and term them the ‘New Science’. Thus, Kepler the astronomer belongs to new science, Kepler the astrologist to the old, Newton the

14 But see Clagett (1978) on Archimedes’ influence already in the Late Middle Ages.
15 See Rossi (1997: 126). Korenjak speaks of a ‘Schulterschluss des Wissenschaftlich-Spekulativen und des Handwerklich-Praktischen, zweier Sphären, die man früher streng voneinander geschieden hatte’ (‘collaboration of the scientific-speculative and the artisanal-practical, two spheres that had previously been strictly separated’; 2016: 235).
16 Besides the arguments against discussed here, it would seem that the main driving force today against having a Scientific Revolution is the wish not to be ‘Eurocentric’ – an unscientific motive to be rejected.
17 Some of them are listed in Rossi (1997: xiv–xvii). For this question in general, see Teich (2015). Crombie (1952) covers the period between the end of Antiquity and the ‘reflowering’ (xi) of science, but rightly sees an essential continuity. Wootton (2015: 2) similarly explains ‘why some think there was no such thing [as the Scientific Revolution], and why it is a sound category for historical analysis’.

mathematical physicist must be contrasted with Newton the alchemist (§4), and so on. Besides, there were dead-end branches, such as Kircher's (§4) kind of universal science, that were much more influential in their day than many of the exponents of the 'Revolution'. Nevertheless, the new mathematico-empirical way of acquiring knowledge is certainly a striking novelty which produced astounding successes, although as emphasised in the motto by Mainzer above, this also had its precursors. The main 'heroes' of the Scientific Revolution belonged to very different schools of thought: from empiricists (Bacon), rationalists (Spinoza), deductivists (Descartes), and mechanicists (Newton), to adherents of the idea that mathematics is the true language of God (Galileo), they all competed during the 'Revolution'.[18] The period of the fifteenth to the seventeenth century can be compared to the twelfth century in its groping in many new directions, some of them with lasting success, others not. Both the thirteenth and the later seventeenth and the eighteenth centuries then consolidated some of the new approaches of the previous century and developed their potential in greater depth. Thus, the eighteenth century appears with a single edifice of science, undoubtedly much larger than before, comprising many of the novel discoveries in early modern times. Of course, important epoch-making discoveries continue after the seventeenth century into our own time, and it is quite arbitrary to close the above list with Newton, but the main blueprint for what is to be considered as scientific and what not was to remain relatively fixed since then. Indeed, it was in the days of Newton that many authors became aware that science and thought had radically changed in the preceding century. It may well be Newton's impressive *Principia* (as late as 1684) that brought the breakthrough for this new combination of methods. In the later seventeenth century, a sense of a new scientific era is palpable in many authors, although there is certainly also the unsettledness of a changing world that subsides after the devastation of the Thirty Years War (1618–1648) and develops into what largely overlaps with the Baroque period.

As already pointed out in the previous chapter (chap. 12 §1), what was definitely revolutionised in the second half of the fifteenth century was the horizon in which Europeans moved, their knowledge of the world outside Europe,[19] their societies, and their means of communicating new ideas through the printing press.[20] All of these processes together are used to define the beginning of modernity and the end of the Middle Ages: their influence on learning and science was

18 Some of these new approaches are explored by Dear (2009).

19 On science in and about the new territories, see Hsia (2001).

20 There are an estimated 28,500 incunabula titles known (Schmitz 2018: 357), printed in less than half a century. See Montecchi (2001) on the relation between early printing and science, especially the list of the first editions of scientific works from Antiquity (705).

obviously very considerable too. Besides the Scientific Revolution, other movements such as antiquarianism appeared:[21] the humanist interest in literary Roman Antiquity also sparked an interest in ancient Roman monuments, ruins, and works of art. Roman life as a whole was studied, a movement which would later grow into German *Altertumswissenschaft*. For instance, the discovery of the remarkably well-preserved remains of Pompeii in 1599 was a major event among intellectuals of the time.

§4 During the Scientific Revolution, international communication among intellectuals was still done nearly exclusively in Latin; even in the case of authors who published important findings in Italian, French, or English first, Latin translations for the international market where soon to follow.[22] Thus, the situation of intellectual bilingualism between mother tongue and the intellectual language Latin, which had already been in existence for more than a millennium,[23] at first only shifted somewhat: discussions with fellow countrymen could now also be held in the vernacular, which had adapted to fulfil this rôle (see chap. 21 below), but international communication was still held in Latin. But what kind of Latin was used by the new scientists?

The topic of scientific Latin style in early modern times has hardly been addressed up to now. Some glimpses are presented in the next section, but more general and safer results about such scientists' Latin can be expected from Korenjak's Noscemus project (*Nova Scientia:* Early Modern Scientific Literature and Latin), which runs from 2017 to 2022.[24] In this section, some specimens of Latin from some writers of the Scientific Revolution are presented.[25] Just as their methods differed significantly, so too did their Latin. Some of the roots of the new approaches in natural science have already been discussed: experimentally minded natural magic (chap. 12) and a Pythagorean view of the (near-)divinity of numbers, well exemplified by Copernicus, Kepler, and Galileo.

Nicolaus Copernicus (1473–1543) was a Renaissance polymath: he studied law, learned Greek, and then studied medicine. But it was mathematics and its

21 Initiated by Flavio Biondo, *Roma triumphans* ([Brescia], ca. 1473; INKA 4424).
22 See Grant (1954); Burke (2007).
23 See Haye (2005).
24 https://wiki.uibk.ac.at/noscemus/Main_Page . It will cover only the natural sciences, and one of its results will be a representative database of some 1,500 works and a digital sourcebook with some 200 digital full texts. There will also be monographs by Korenjak and his collaborators.
25 Portraits of eleven of the most important natural scientists of this time can be found in Petruccioli (2001–2004: 5:part 3). Olschki (1919–1927: 2:65–111) reviewed the Latin style of some important authors.

application to the movement of the heavenly bodies that made him famous.[26] His famous major work, *De revolutionibus orbium coelestium*, was finished on his deathbed (Norimbergae, 1543). Much of it consists of very theoretical mathematical calculations and lists of observational data, but in some parts (especially book I) the author shows his enthusiasm for Renaissance Platonism and his love of the Greek classics by positing the Sun, the *visibilis deus* as he calls it, at the centre of the universe (*De revolutionibus orbium coelestium* I.10, ed. Lerner, Segonds & Verdet, vol. 2, p. 38):

> *Quis enim in hoc pulcherrimo templo lampadem hanc in alio meliori loco poneret, quam unde totum simul possit illuminare? Siquidem non inepte quidam 'lucernam mundi', alii 'mentem', alii 'rectorem' vocant. Trismegistus 'visibilem Deum', Sophoclis Electra 'intuentem omnia'. Ita profecto tanquam in solio regali Sol residens circumagentem gubernat Astrorum familiam.*
> 'Who would position that light [the Sun] in this most beautiful temple [the world] at a better spot than the one from which it can illumine the entire world at once? If indeed some call Him not unfittingly "lamp of the world", others "mind", others "ruler", Trismegistus "visible god", Sophocles' Electra "the all-seer", so, assuredly, the Sun rules the entire family of revolving heavenly bodies as if seated in a kingly throne.[27]

Perhaps as an expression of caution in times of religious upheaval, his printer Osiander added an alleviating preface claiming that the entire book was only a theoretical exercise. In his introduction *[a]d lectorem, de hypothesibus huius operis* (Norimbergae, 1543 edition, before pagination),[28] he states among other things:

> *Neque enim necesse est, eas hypotheses esse veras, imò ne verisimiles quidem, sed sufficit hoc unum, si calculum observationibus congruentem exhibeant.*
> 'It is not necessary that these hypotheses be true, not even probable; this one thing suffices: if the calculations are in agreement with observation.'

The book's success was at first rather limited. As Goddu (2010: 406–409) points out, the reasons for this were more of a scientific than of a religious nature. Only with Galileo's and Kepler's (1571–1630) further work (leading to the discovery of the famous Kepler laws) was the theory in itself made plausible. Kepler too was deeply immersed in Renaissance neo-Platonism. Incidentally, Kepler provides a

26 For an introduction to his life and thought, see Goddu (2010). The amount of literature about Copernicus and the other major heroes of the Scientific Revolution is enormous.
27 A similar Sun theology is further elaborated into a veritable Sun-religion, where God resides in the Sun and the souls of the dead in the stars, by Tommaso Campanella, *Civitas solis*, nearly a century later.
28 https://www.e-rara.ch/zut/content/pageview/124056 .

list of what he considered sciences that fits in very well with the broad 'German' approach we met above (see chap. 1; *Somnium*, nota 35, ed. Frisch, p. 43):

> *1. metaphysica, 2. physica, 3. ethica, 4. astronomia, 5. astrologia, 6. optica, 7. musica, 8. geometria, 9. arithmetica.*

The divine nature of geometric entities is pointed out emphatically by Galileo Galilei (1564–1642), who often wrote in Italian.[29] He states (*Il saggiatore* 6, ed. Besomi et al., p. 119):[30]

> La filosofia è scritta in questo grandissimo libro, che continuamente ci sta aperto innanzi agli occhi (io dico l'Universo), ma non si può intendere, se prima non s'impara a intender la lingua, e conoscer i caratteri ne' quali è scritto. Egli è scritto in lingua matematica, e i caratteri son triangoli, cerchi ed altre figure geometriche, senza i quali mezzi è impossibile intenderne umanamente parola; senza questi è un aggirarsi vanamente per un oscuro laberinto.
> 'Philosophy is written in this great book, which lies constantly open before our eyes (I mean the Universe), but you cannot understand it unless you first learn to understand its language and to know the characters with which it is written. It is written in mathematical language, and the characters are triangles, circles, and other geometric figures, without which means it is impossible for humanity to understand it; without them, there is a vain wandering through a dark labyrinth.'

Thus, for Galileo God's language is mathematics – not, as it used to be believed in the Middle Ages, Hebrew or any other human language. He also expounded this in detail in his *Systema cosmicum,*[31] his famous discussion of whether geocentricism or heliocentricism was to be preferred. At the end of the first day of the discussion, Salviati (who speaks for Galileo against the fictitious Aristotelian Simplicius) argues as follows (Londini, 1663 edition, p. 137):

> *Ut ergo me rectius explicem, aio, quod ad veritatem, cuius cognitio mathematicis demonstrationibus paratur, eandem illam esse cum ea quam divina sapientia cognoscit. Id vero tibi facile largiar, modum illum, quo Deus cognoscit infinitas propositiones, quarum nos paucas aliquas cognoscimus, summe excellentiorem esse nostro modo, qui ratiocinando de conclusione progreditur in conclusionem, cum Dei modus simplici absolvatur intuitu.*

29 On his Latin, see Berno (2006/2007).
30 This work is a prime example of how certain modern circles write one-sided hagiography of their scientific heroes. In it Galileo wrongly and with much bile argues against the Jesuit Orazio Grassi that comets are sublunar phenomena. This and other failures of Galileo are often swept under the rug.
31 This is the Latin translation of Galileo's *Dialogo dei due massimi sistemi* by his friend Matthias Bernegger. Italian was clearly not acceptable for an international reception; Kepler, for instance, did not read Italian. For the Italian text, cf. Galileo, *Opere*, ed. Flora, p. 110. On this work, see https://wiki.uibk.ac.at/noscemus/Systema_cosmicum.

'In order that I explain myself better, I say that concerning truth, whose knowledge is provided by mathematical proofs, it is the same as the one that divine Wisdom [i.e. God] knows. I grant you freely that the manner in which God knows infinite propositions, of which we know but few, is by far better than ours, which has to proceed by reasoning from one conclusion to the next, while God's manner is resolved by mere looking.'

Whereas Galileo stands for the mathematical approach, a new inquisitive and empirical spirit and a pessimistic outlook on what is already known is shown by the English Lord Chancellor Francis Bacon (1561–1626) in his *Novum organon* (praef., ed. Krohn, p. 12) from 1620:

De statu scientiarum, quod non sit foelix aut majorem in modum auctus; quodque alia omnino quam prioribus cognita fuerit via aperienda sit intellectui humano, et alia comparanda auxilia, ut mens suo jure in rerum naturam uti possit.
Videntur nobis homines nec opes nec vires suas bene nosse; verum de illis majora quam par est, de his minora credere. Ita fit, ut aut artes receptas insanis pretiis aestimantes nil amplius quaerant, aut seipsos plus aequo contemnentes vires suas in levioribus consumant, in iis quae ad summum rei faciant non experiantur. Quare sunt et suae scientiis columnae tanquam fatales; cum ad ulterius penetrandum homines nec desiderio nec spe excitentur.
'That the status of the sciences is not prosperous, nor advancing in a great way, and that a completely different path has to be trodden by the human intellect than the one known to our predecessors, and other helps provided in order that the mind be able to use its proper laws toward the nature of things.
It seems to me that men do not know either their property or their possibilities well: they think too highly of the former and too low of the latter. Hence it happens that either they esteem the received arts insanely highly and seek no further, or else that they belittle themselves more than is just and expend their strength on minor matters and do not exercise their powers in things that strive for the highest. This is like the pillars of fate for science, because men are encouraged to penetrate more deeply neither by desire nor by hope.'

Bacon is often hailed as the father of the empirical method. Although he was not active as a scientist himself, his methodological considerations were indeed influential. His scepticism is related to a disdain for scholastic 'sophistry'. Much of his (unfinished) work consists of aphorisms, such as the following (no. 14, ed. Krohn, p. 86):

Syllogismus ex propositionibus constat, propositiones ex verbis, verba notionum tesserae sunt. Itaque si notiones ipsae (id quod basis rei est) confusae sint, et temere a rebus abstractae; nihil in iis, quae superstruuntur, est firmitudinis. Itaque spes est una in inductione vera.
'A syllogism consists of propositions, propositions of words, and words are the tokens of notions. Thus, if the notions themselves (which are the basis of the matter) are confused, and rashly abstracted from things, nothing of what is built upon them is firm. Thus, our only hope is true induction.'

René Descartes (1596–1650, in Latin ‘Cartesius’) was one of the early adopters of French in scholarly writing. Most of his correspondence[32] and many of his treatises are written in French (*Opera*, ed. Adam et al.). Many works were translated into Latin before long, either by himself or by others. Descartes is today mostly remembered as a philosopher, but he also proposed a new mechanical worldview based on vortices of matter, and made important contributions to mathematics and physics. In fact, the philosopher and the scientist have often been considered separately.[33] Like Lullus, he envisaged a universal science, *mathesis universalis*. His *Principia philosophiae* (1644) was first published in Latin. It shows well that for Descartes, philosophy and natural science go hand-in-hand. Much of the text is concerned with his vortex theory and with the mechanics of the solar system. An excerpt from it, here a passage about sunspots, will serve to illustrate his language. The geometric relations are illustrated with a graphic (fig. 22; *Principia philosophiae,* Amstelodami, 1692 edition, p. 104):

> *Quomodo materia primi elementi per istos meatus fluat.*
> *Ita igitur materia primi elementi utrimque ex polis per istos meatus ad sidus I potest peruenire; ac quia eius particulae striatae caeteris sunt crassiores, ideoque maiorem habent uim ad pergendum secundum lineas rectas, non solent in eo manere, sed ingressae per f, protinus egrediuntur per d, atque ibi occurrentes globulis secundi elementi, uel materiae primi a B uenienti, non possunt ulterius pergere secundum lineas rectas, sed, in omnes partes reflexae, per aetherem circumfusum xx uersus hemisphaerium efg reuertuntur; et quotquot ingredi possunt meatus maculae, uel macularum, quae ibi sidus istud tegunt, per illos rursus progrediuntur ab f ad d; sicque assidue per medium sidus transeundo, et per aetherem circumfusum redeundo, quendam ibi quasi uorticem componunt.*
> ‘How matter of the first element flows in such trajectories.
> Thus matter of the first element can reach the star (I) from both sides in such trajectories, and because its furrowed particles are denser that others, they have more force to move in straight lines, they do not stay in it [the star], but if they have entered at f, they will directly exit at d, and there meeting particles of the second element or matter of the first coming from B, they can no longer move in a straight line, but they are reflected everywhere by the surrounding aether (x), they return toward the hemisphere efg. And as many trajectories of a spot or spots, which can cover the star there, can enter, they exit again from f to d. Thus, they pass constantly through the middle of the star and return from the surrounding aether, which they form like a vortex [around the star].’

32 An exception is that with his opponent Gisbertus Voetius.
33 Rodis-Lewis (1987) is a collection of essays on his approaches in the natural sciences. For an introduction to Descartes the scientist, see Armogathe (2002).

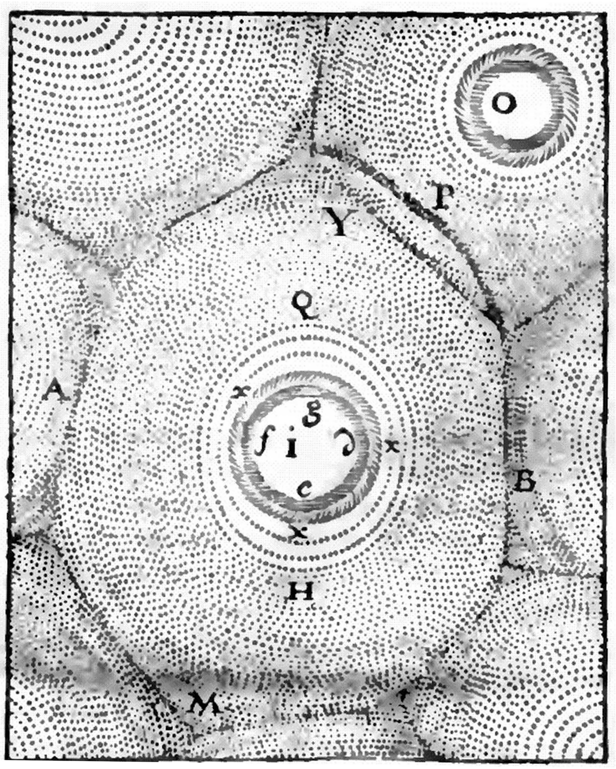

Fig. 22: The Sun (centre) in stellar vortices.

Descartes's contemporary Athanasius Kircher (1602–1680) was a German Jesuit who became the Habsburg court mathematician (as Kepler had been) but finally ended up in Rome at the Jesuit headquarters, the Collegium Romanum, where he taught mathematics, physics, and oriental languages.[34] The Collegium Romanum was actually very similar to the kind of scientific institution free from state control that Francis Bacon had envisioned a few decades previously (1627, in *New Atlantis*):[35] all information from the near-worldwide Jesuit missions converged there, furnishing the inquisitive Kircher with scientifically interesting data and objects. His collection of *curiosa* grew into one of the earliest museums, the *museo kircheriano*.[36] As an example of Kircher's way of practising science, we will consider his

34 On the Jesuits' relation to science, see Feingold (2003b).

35 Although, of course, Bacon would not have approved of Church control either.

36 Its exhibits are now spread among several Roman museums. See Findlen (2003).

China illustrata, which was the most scientific general treatment of Chinese culture then in existence and was to be very influential in Europe's perception of China.[37] Some background is required: Kircher's work stands at the beginning of scientific sinology in Europe. Indeed, European sinology may be said to begin with the discovery of the famous 'Nestorian Stele' in Xi'an (1623 or 1625), which proved Christian presence in China since the seventh century. Kircher had first made its text known in Europe in his *Prodromus coptus* (pp. 54–69, 74–85).[38] In his 'summa', *China illustrata*, thirty years later, Kircher reproduced the rather faulty initial translation of the stele's text, but this time he added a word-for-word translation from the Chinese that is better. In general, the text was clearly hastily penned and is surprisingly sloppy.[39] Kircher's main scientific contribution of his own lay in the reading of the Syriac parts of the stele's inscription; for the Chinese, he relied on Jesuit collaborators. Indeed, *China illustrata* is based on the contributions of many Jesuit missionaries working in the regions described and is clearly a community work. Besides the stele, it also treats Chinese geography in a scientific way: Kircher uses the geographic coordinates of mentioned places when known to him, and admits doubt in unclear matters. On the other hand, he fails to be consistent in simple things such as the spelling of names.[40] Curiosa are still an important part of the work, but they are treated in a relatively scientific spirit, more like Seneca did than, say, Solinus. Kircher includes a comprehensive bibliography of other Jesuits (pp. 117–121). Part III, chapter 1 (pp. 129–151) presents a comparative study of idols, reaching the (wrong) conclusion that Chinese idolatry can be traced back to Egyptian idolatry. A sample (p. 131; see Wengchao Li 2020: 86–87):

> *TRes igitur Sinarum Libri Orbis terrarum sectas numerant; sic enim vocant Regnum suum una cum vicinis adiacentibus locis, alias enim minime norunt.*
> *Prima est Literatorum; altera Sciequia; tertiam Lançu vocant. Ex his tribus aliquam Sinæ omnes & reliqui populi contermini, qui Sinarum characteres habent, profitentur; quales sunt Iapones, Coriani, Tonchini & Cocincinenses populi, de quibus postea dicemus.*
> 'The books of the Chinese world thus count three religions, for this is what they call their own kingdom together with the adjacent places; they do not know others.

37 There is now a commentary on the work in Wengchao Li (2020).

38 The European literature about this stele from its discovery to today is astonishingly large. The state-of-the-art edition and discussion is Pelliot (1996: 108–110, 116–118 on Kircher's two translations).

39 For instance, on p. 29 a wrongly printed parenthesis makes it unclear what is Kircher's (pertinent) comment, and what stands on the stele: *[...] (alludit ad hoc secta Pagodum & Literatorum)* [erroneous parenthesis] *[...] comprehendi queat* [correct position for the parenthesis].

40 *Cingiscan* is followed by *cham*; for the un-Latin sound /ʃ/, *sch* is used if the source was a German missionary, *sci* if an Italian, even for one and the same Chinese name, producing unnecessary obscurity.

> The first is the one of the literati [Confucians], the second of the *śākyamuni* [Buddha], the third is called Laozi [Taoism].[41] All Chinese and the other adjacent peoples who use Chinese characters confess one of these three. These are the Japanese, Koreans, northern Vietnamese, and southern Vietnamese peoples, about which we will speak later.'

His language in this work is, as is typical for him, full of quotations in many languages and alphabets; his Latin in the preface is syntactically very complicated, although it rather fails to reach Ciceronian elegance. In the rest of the work, it is plainer. Unlike in many other scientific texts (see chap. 18 §3), the *ablativus absolutus* is a common feature, sometimes even one within another one (p. 88):

> *Novo itaque Pontifice, sub nomine Gregorii X. Rudolpho imperante, unanimibus Cardinalium suffragiis electo, Anconam revertuntur.*
> 'As then a new Pope with the name Gregory X had been elected unanimously by the votes of the cardinals, during the reign of Emperor Rudolph [I of Germany], they returned to Ancona.'

Benedictus Spinoza (1632–1677), born into a Jewish family (although later expelled from the community), received both a Hebrew and a Latin education. He earned his livelihood as a lens-maker. His importance lies mostly in the human sciences and philosophy: political thought, biblical studies, ethics. Euclid's axiomatic method inspired him to try similar approaches in the human sciences, especially in his *Ethica ordine geometrico demonstrata* ([Amsterdam], 1677). In biblical studies he demonstrated that the five books of Moses cannot have been written by Moses (which did not win him friends). His philosophy emphasising the immanence of God and the importance of human freedom was also very controversial but much read, especially among German philosophers. There was no lasting success for his axiomatic approach in the human sciences. His language and approach can be illustrated by this typical excerpt (*Ethica ordine geometrico demonstrata* IV.71, ed. Bartuschat, p. 500):

> *Soli homines liberi erga invicem gratissimi sunt.*
> *DEMONSTRATIO. Soli homines liberi sibi invicem utilissimi sunt et maxima amicitiae necessitudine invicem iunguntur (per prop. 35. huius et eius coroll. 1.), parique amoris studio sibi invicem benefacere conantur (per prop. 37. huius). Adeoque (per aff. defin. 34.) soli homines liberi erga se invicem gratissimi sunt. Q.E.D.*

41 The point made above about the spelling is nicely illustrated here: *Sciequia* will have come from an Italian missionary, *Lançu* from a Portuguese one whose pronunciation of *Laozi* may have been wrongly taken by another Romance-speaker as nasalising an *n* (compare e.g. Portuguese *cão* for *canis*).

> 'Only free men are truly grateful to one another.
> Proof. Only free men are of greatest use to one another and are joined by greatest necessity of friendship (as from theorem 35 of this book and its first corollary), and they try with equal fervour to do good to one another (as from theorem 37 of this book). And thus (through definition 34 on affects) only free men are truly grateful to one another. Q.E.D.'

Similar methods were used by Isaac Newton (1643–1727) with greater success. He may have been the man to unite the two new positions of empiricism and mathematisation firmly and lastingly. His strictly mathematical theory of gravitation, meant to hold equally in all parts of the universe, revolutionised physics. Newton is also famous for his strong criticism of scientists who forged hypotheses on uncertain grounds (intending especially Descartes); nonetheless, he himself believed, for instance, in absolute space and time because of his views of God constituting them.[42] Newton, *Principia mathematica*, *Praefatio ad lectorem*[43] states:

> *Cum veteres mechanicam (uti auctor est Pappus) in rerum naturalium investigatione maximi fecerint, et recentiores, missis formis substantialibus et qualitatibus occultis, phaenomena naturae ad leges mathematicas revocare aggressi sint: visum est in hoc tractatu mathesin excolere quatenus ea ad philosophiam spectat.*
> 'As the ancients (as Pappus testifies) made great account of mechanics[44] in the investigation of natural things, and more recent scientists, after dismissing substantial forms and occult qualities, have undertaken to reduce the phenomena of nature to mathematical laws, it will be seen that mathematics is applied in this treatise as far as it regards natural philosophy.'

Later in the book, Newton's language soon becomes very mathematical and formal, as the following example concerning circular motion in viscous media illustrates (*Principia mathematica* II.4, lem. III, commented edition, p. 536):[45]

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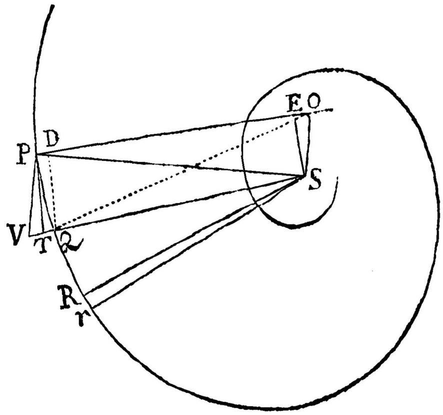
42 Already mentioned above (chap. 4 §3). Burtt (1954); Wagner (1969); Wagner (2011); Harper (2011). In *Principia mathematica* I, def. VIII, scholium (1687 edition, p. 5), Newton defines *tempus absolutum* and *spatium absolutum*; besides, he claims that *[s]patium absolutum natura sua absque relatione ad externum quodvis semper manet similare et immobile* ('absolute space always remains similar and immobile by its own nature without reference to anything external') – all of which are metaphysical hypotheses, and are, in fact, no longer shared among physicists today.
43 Before pagination; p. x in the commented edition of 1833. See on this work https://wiki.uibk.ac.at/noscemus/Philosophiae_naturalis_principia_mathematica.
44 On the next page, Newton defines mechanics as *rationalis Scientia Motuum qui ex viribus quibuscunque resultant, & virium quæ ad motus quoscunque requiruntur* ('the rational science of movements which result from any forces and of the forces required for any movements').
45 This lemma discusses a property of the logarithmic spiral, in polar coordinates $r = ae^{b\theta}$. Jacob Bernoulli (1655–1705) called it the *spira mirabilis* and wanted it inscribed on his gravestone with the motto *eadem mutata resurgo* ('although changed, I arise as the same').



Sit PQRr Spiralis quæ secet radios omnes SP, SQ, SR, &c. in æqualibus angulis. Agatur recta PT quæ tangat eandem in puncto quovis P, secetque radium SQ in T; & ad Spiralem erectis perpendiculis PO, QO concurrentibus in O, jungatur SO. Dico quod si puncta P & Q accedant ad invicem & coeant, angulus PSO evadet rectus, & ultima ratio rectanguli TQ × 2PS ad PQ quad. erit ratio æqualitatis.
Etenim de angulis rectis OPQ, OQR subducantur anguli æquales SPQ, SQR, & manebunt anguli æquales OPS, OQS. Ergo circulus qui transit per puncta O, S, P transibit etiam per punctum Q. Coeant puncta P & Q, & hic circulus in loco coitus PQ tanget Spiralem, adeoque perpendiculariter secabit rectam OP. Fiet igitur OP diameter circuli hujus, & angulus OSP in semicirculo rectus. Q.E.D.
'Let PQRr be a spiral which cuts all the radii SP, SQ, SR, etc. in equal angles [i.e. a logarithmic spiral]. The straight line PT be drawn, which touches the spiral in a point P, and cuts the [prolonged] radius SQ in T. Perpendicular lines to the spiral PO and QO being drawn, meeting in O, this point be joined to form SO. I claim that if the points P and Q approach one another and [finally] coincide, the angle PSO will become a right angle, and the final ratio of the rectangle TQ · 2PS to PQ^2 will become the ratio of equality [i.e. TQ · 2PS = PQ^2].
[Proof] Indeed from the right angles OPQ, OQR let there be subtracted the equal angles SPQ, SQR and there will remain equal angles OPS, OQS. Therefore a circle which passes through points O, S, P will also pass through point Q. Let the points P and Q coincide and this circle will touch the spiral in the place of coincidence PQ and will therefore cut the right line OP perpendicularly. OP will become a diameter of this circle, and the angle OSP will become a right one as it stands in a semicircle. Q.E.D.'[46]

Like Euclid, Newton often used letter symbols to denote mathematical objects, and the many graphics included are often necessary to understand the geometric facts.[47] It has been claimed that English nominal scientific style owns much to

46 We omit the second part of the proof.
47 For Euclid see chap. 22 §4 below.

Newton's Latinising English.[48] The work is very formalised, consisting of lemmata, theorems, formulae, and the like. The language is very nominal, participles and ablative absolutes are used to formulate conditions, finite verbs are often just the copula or impersonal passives, like in modern English science books, and besides (due to the topic) the verb *movere* is common. It would seem that not only Newton's methods became paradigmatic for the New Science but also his language. His book reads like a modern mathematics or physics book. But Newton's approach is still much more geometric than that used by physicists today; only rarely does he use equations ('=' appears 87 times), and much more often he uses ratios to express what would now be expressed by an equation.[49]

Newton's strong interest in theology and the Old Testament could not lead to publications because his heretical anti-Trinitarian views were punishable by death in England. His third main interest was alchemy.[50] The question of the relation between his physical and his alchemical studies has often been discussed, Dobbs (1975: 210–213) sees the latter as important for the conception of 'force' in the former, among other things. At any rate, it should not be concluded overhastily from the fact that Newton did not publish his alchemical works that they mattered little to him. Dobbs (194–196) makes it more plausible that he believed their content to be too dangerous to be publicly accessible. The language in his alchemical notes stands in stark contrast to that of the *Principia*. Here is an arbitrary example quotation from his alchemical manuscripts:[51]

> *Totum opus in unicâ re consistit. Educ salem e metallis: qui est unicus clavis nam omnis generatio fit ex spermate. Metalla ignem non passa debent sumi. Arca arcanorum.*
> 'The entire work consists in only one thing: lead salt out of metals, which alone [the salt] is the key, for all generation comes from seed. Metals that have not suffered fire must be used. Chest of secrets.'

Chemistry had to wait another half-century to undergo a process of formalisation of the kind that Newton performed for gravitation theory. Apparently, he failed to see the use of his own approach in the field of the transmutation of chemical substances. Both his alchemical and theological works would have fared much worse

48 See Banks (2008: 59–63), who studies nominalised processes in an excerpt from the *Principia* and quotes further literature.

49 The equals sign '=' only gained wide acceptance in the early eighteenth century; see Cajori (1928–1930: 1:305).

50 Dobbs (1975) studies this facet of Newton in depth. His manuscripts are online at http://webapp1.dlib.indiana.edu/newton/.

51 Cambridge University, King's College Library, Keynes MS. 12, fol. 1r, online at http://webapp1.dlib.indiana.edu/newton/mss/norm/ALCH00001/

than his physical ones had they not been completely ignored by posterity. We shall return to Newton's seemingly contradictory scientific approaches below (§6).

Gottfried Wilhelm Leibniz (1646–1716) read, spoke, and wrote many languages, but his main works are written in Latin, French, and German. Besides his important contributions to mathematics, physics, and philosophy, his interest in languages and linguistics is evident; he even considers active Latin language engineering by, for instance, introducing what he calls *tempora nominum*[52] such as *amavitio* and *amaturitio* for past and future 'loving' respectively. In this, like in his combinatorics, he seems to have been influenced by Lullus (see chap. 12 §5). Leibniz is clearly interested in Latin only as a vehicle for scientific content, not in style and beauty. Indeed, his language looks quite scholastic, as this example shows (*De vero et falso* 9, Akademieausgabe, ser. 6, vol. 4, p. 738):

> *Affirmatio et negatio negationis aequipollent. Est axioma fluens ex ipso significatu τοῦ non, seu particulae negativae, cujus hic est usus, ut geminatione semet ipsam tollat.*
> 'Affirmation and the negation of negation are equivalent. This is an axiom following directly from the meaning of "not", that is, the particle of negation which is used here, which by being doubled cancels itself out.'

Besides the conspicuous Greek article used here,[53] Leibniz often uses other Greek terms in his writings that were apparently felt to be hard to express in Latin, especially compounds (some rather arbitrary examples: ὀνοματοποεῖν, καρδιογνώστης; 6:4:343, 1519) but also words that could easily be said in Latin (παραφράζειν, κατ' ἐξοχήν; 6:4:117, 1176) and look more 'ornamental'. Leibniz may be said to be a typical exponent of academic Latin (see chap. 18 §9). Especially in his contributions to the human sciences, quotations in countless languages and alphabets, formulas, and diagrams similar to those in Kircher are to be found.

To conclude this overview, three texts outside the usual timespan of the Scientific Revolution are considered, two early and one late. Leonhart Fuchs's *De historia stirpium* (1542)[54] reached a new level of accuracy in botanical description, helped by engravings and thus by the then still relatively young technique of book-printing. The author has to justify the illustrations (p. [17]) against *contemptores picturae*. The work proper is preceded by a very humanist dedicatory letter quoting huge numbers of antique Greek and Latin authorities. Here is an example from the chapter *De cannabe* (Basileae, 1542 edition, p. 392):

52 In Leibniz, *Opuscules*, p. 289.
53 On this surrogate article, see chap. 24 §2.
54 See https://wiki.uibk.ac.at/noscemus/De_historia_stirpium.

ΚΑΝΝΑΒΙΣ Graecis, Cannabis Latinis, Barbaris & uulgo Canapus dicitur, Germanis autem Hanff. Genera: Cannabis duo sunt genera. Vna enim satiua est, quam Gręci σχοινοστρόφον, quod magni in uita usus sit ad robustissimos funes texendos. Germanis zamer Hanff dicitur. Altera syluestris, quam Latini Terminalem uocant, Germani wilden Hanff. Forma: Satiua Cannabis folia fert fraxino similia, grauis odoris, caules longos, inanesque, semen rotundum. Syluestris uerò uirgas fundit Altheae similes, nigriores, asperiores & minores, cubitali altitudine. Folia satiuae similia, asperiora & nigriora. Flores subrubeos, Lychnidi similes. Semen & radicem Altheæ similia. Eius effigiem uidere nondum licuit. Locus: Satiua, in locis cultis sata prouenit. Sylvestris in sylvis & asperis locis, Apuleioque teste, iuxta semitas & sepes nascitur. Tempus: Herba ad usus medicos carpitur dum maxime uiret. Semen autem eius, Plinio auctore, cum maturum est, id quod prope autumni aequinoctium accidit. Temperamentum: Admodum calefacit & exiccat.[55]

'In Greek κάνναβις, in Latin *cannabis*, among uncultured people and vulgarly called *cannapus*, in German *Hanf*. Kinds: there are two kinds of hemp. One is cultivated, called σχοινοστρόφον[56] by the Greeks, it is very useful in life for manufacturing very robust ropes. In German *zahmer Hanf* [tame hemp]. The other is wild, the Latins call it *terminalis*, the Germans *wilder Hanf* [wild hemp]. Form: cultivated hemp has leaves similar to ashes, a strong smell, long and hollow stalks, round seeds. The wild one spreads twigs similar to mallow but blacker, rougher, smaller, one cubit in height. The leaves are similar to the cultivated kind. The flowers reddish, similar to campion. Seeds and the root similar to mallows. I have not yet managed to see it. Place: the cultivated kind appears when sown, the wild one in forests and rough places. According to Apuleius, it grows close to paths and fences. Time: The herb is collected for medicinal purposes when it is most green, but its seed, according to Pliny, when it is mature, which occurs close to the autumnal equinox. Temperament: it strongly heats and dries out.'

This same style of description is used for all the approximately five hundred plants covered. The medicinal background and the language would still seem rather mediaeval, but the quality of the descriptions and the approach of comparing plants look modern and were groundbreaking for botany. The book is purely descriptive in method, but its way of describing plants has remained in use ever since (more details in chap. 15 §5 below). Fuchs's major antique predecessor was Dioscurides (ca. 40–90); a late antique illustrated copy of his work *De materia medica* has survived.[57] The importance of descriptive science is sometimes underestimated:[58] gathering reliable data is a very important step in science. Often, great theoretical advances could only be made after much accurate description had been gathered. In the case of botany, a further crucial step will be Linnaeus' nomenclature (chap. 15 §5). Today, of course, botany has long ceased to be a

55 A list of uses from antique authors follows.

56 Literally 'rope-maker'. The term is mentioned in Dioscurides.

57 Ed. Mazal, also with facsimile and commentary. See fig. 28 below for an example.

58 On the 'science of describing', see Ogilvie (2006).

‘merely’ descriptive science. The following work was also of crucial significance; its advances are both in description and in theory.

Fig. 23: Illustration of the male hemp plant from Fuchs (1542 edition, p. 393).

Andreas Vesalius’ *De humani corporis fabrica*[59] was groundbreaking for human anatomy: again, its precision and its very high quality illustrations, which are rightly famous, make it stand out (an example is printed in figure 24; it does not belong to the quoted text). A random excerpt will give an impression of his unusual Latin (*De humani corporis fabrica* I.60, *De ossium numero*):

> *Parum dubito plerosque alicubi a me ossium quoque numerum desideraturos: quibus nullum aliud consilium dari uelim, quam, ut ex singulis huius libri Capitibus illum petant. prolixius enim esset, hic omnia recensere. Quamuis ne tantillum laboris subterfugisse uidear, non enu-*

59 See https://wiki.uibk.ac.at/noscemus/De_humani_corporis_fabrica.

meratis appendicibus, et ossibus ita ut in prouectioris ætatis hominibus se habent, constitutis, ad hunc modum ea recensere nihil impediet.
'There is little doubt that there will be many wishing to hear from me the number of all the bones. I would give them no other advice than to seek it out from the individual chapters of this book, for it would be too lengthy to muster them all again. However, in order not to seem to have fled such a trifle of work, without counting appendices and considering the bones as they are in adult age, nothing impedes counting them in the following way.'

Vesalius' Latin is definitely classicist, with complicated formulations and sometimes rare words (such as *tantillum* in this passage). The above paragraph, which is quite typical, could be reduced to one short sentence without losing any scientific information. We will see that this kind of humanist Latin in the sciences is an exception.

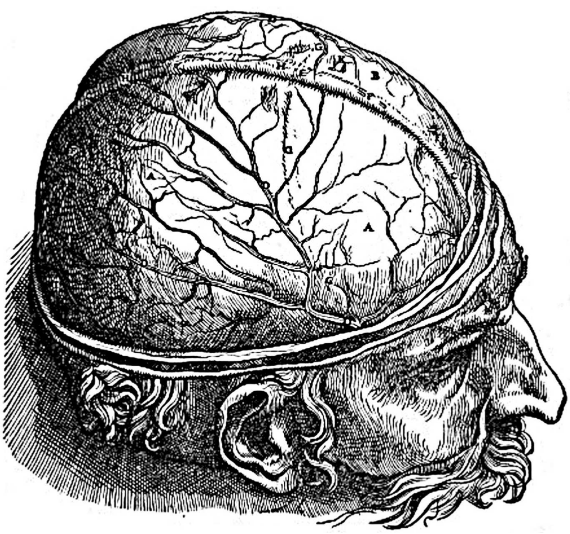


Fig. 24: Blood vessels in the scalp, from Vesalius (*De humani corporis fabrica* VII, beginning, 1543 edition, p. 605).

The Jesuit Rogerius Josephus Boscovicius (1711–1787) from Ragusa (modern Dubrovnik) invented the Boscovich curve, with which he proposed a unified physical force for all matter. He conceived it as a complicated mathematical function (see fig. 25), described in *Theoria philosophiae naturalis redacta ad unicam legem virium in natura existentium* (1763 edition, p. 16) thus:

materiam constantem punctis prorsus simplicibus, indivisibilibus, & inextensis, ac a se invicem distantibus, quæ puncta habeant singula vim inertiæ, & præterea vim activam mutuam pen-

dentem a distantiis, ut nimirum, data distantia, detur & magnitudo, & directio vis ipsius, mutata autem distantia, mutetur vis ipsa, quæ, imminuta distantia in infinitum, sit repulsiva, & quidem excrescens in infinitum: aucta autem distantia, minuatur, evanescat, mutetur in attractivam crescentem primo, tum decrescentem, evanescentem, abeuntem iterum in repulsivam, idque per multas vices, donec demum in majoribus distantiis abeat in attractivam decrescentem ad sensum in ratione reciproca duplicata distantiarum.
'that matter is unchangeable, and consists of points that are perfectly simple, indivisible, of no extent, and separated from one another; that each of these points has a property of inertia, and in addition a mutual active force depending on the distance in such a way that, if the distance is given, both the magnitude and the direction of this force are given; but if the distance is altered, so also is the force altered; and if the distance is diminished indefinitely, the force is repulsive, and in fact increases indefinitely; whilst if the distance is increased, the force will be diminished, vanish, be changed to an attractive force that first of all increases, then decreases, vanishes, is again turned into a repulsive force, and so on many times over; until at greater distances it finally becomes an attractive force that decreases approximately in the inverse ratio of the square of the distances.'[60] (Trans. Child, p. 17)

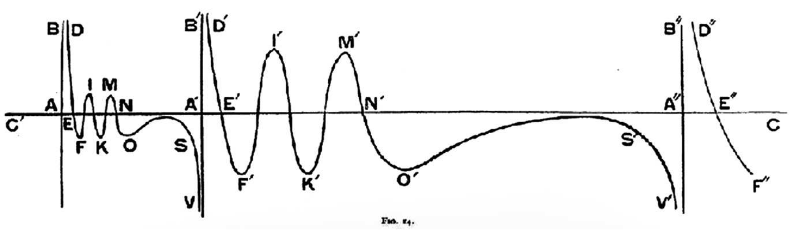


Fig. 25: One of several representations of the Boscovich curve by Boscovich himself (*Theoria philosophiae naturalis*, ed. Child, p. 137).

This is a complicated sentence (containing four *ablativi absoluti*) describing a complicated function. This Jesuit author was another advocate of using 'good' Latin in the sciences – possibly a reason why he has largely been neglected and is today little known despite the obvious importance of his ideas.[61] There were many outstanding scholars and poets among the Jesuits of Ragusa, all still writing in Latin. For instance, the poet Benedictus Stay (1714–1801) wrote hexametric poems on the history of philosophy (mentioned in chap. 5 §2 above); he was a friend and pupil of Boscovich.

60 Thus, Boscovich intended to see Newtonian gravity only as approximately correct, like Einsteinian relativity does today.
61 Ullmaier (2005) tried to change this.

The revolution's Latin

§5 Latin was still the near-exclusive medium of communication, at least if the content was meant to be received internationally. Only some first conclusions about these texts' Latinity can be offered, as preliminary studies are missing.[62] Recently, the Neo-Latin language in general has finally begun to receive more attention. The trend seems to be that it was much less static and 'classical' than was previously thought, even in the belles-lettres. Helander studied Neo-Latin neologisms and found an 'eclectic attitude' (2014: 39). This does not differ much from scholastic practice, with the possible exception that Greek coinings became more frequent and were now nearly always formed correctly. Obviously, this is a consequence of a much more common and thorough learning of Greek after the Renaissance.[63] Neologisms of non-Greek origin can still be found, especially Germanic and Arabic, as in mediaeval times, but their numbers would seem to decrease. Among Latin internal means of forming new words, the suffixes for denoting qualities (*-tas,* chap. 11 §2) and processes (*-tio*), encountered above as being conspicuous in scholastic Latin, are still very dominant (Helander 2014: 43). The typically scholastic nominal style is still often found in scientific Neo-Latin, where one finds rather

> *Respiratio fit cum pectoris et sterni contractione*
> 'Breathing happens with contraction of the chest and the breast-bone'

than

> *respirant et eodem tempore pectus et sternum contrahuntur,*

which would be rhetorically superior; 'factual texts differ considerably from the ethos of ancient oratory and historiography' (Helander 2014: 45). Such suffixes will be part of the corpus studies below (chap. 18 §2). The Latin of the authors presented above is very far from uniform. Some of them actively worked on their language. Vesalius consciously used Latin names for the different parts of the body, which before him either had no name or only a Greek one. In general, Vesalius is unusual among these authors in striving to write a rhetorical, humanist Latin[64] –

62 Ogilvie (2015: 264) may somewhat overemphasise the success of the humanist movement in changing university Latin, as we shall see.
63 Some examples in Helander (2014: 40–41), who stresses that this procedure was especially common in medicine and biology.
64 See Korenjak (2016: 248). Olschki (1919–1927) praises Vesalius' Latin: 'Erasmus der Medizin' (2:95), says more about his classicist syntax (99), and comments on the 'Paarung vom neuen Forschergeist und antiquarischer Bildung' ('combination of the new spirit of research and antiquarian education'; 101).

one that apparently was too difficult for some of his students, for easier *réécritures* were circulating.[65] Boscovich can be added to this group of 'humanist' scientists. In contrast, Fuchs's Latin looks very pedestrian and mediaeval; that of Leibniz often looks rather more scholastic than he himself would be happy to admit. The Latin of these authors differs widely, but even the Latin within their works often differs strongly, depending on the part of the work. Paratexts such as dedications and introductions are often written in more humanistic Latin; the scientific core of the work is usually in technical Latin without much concern for the beauty of language. Despite these many differences, there are still not only external common features – such as a stricter methodology and terminology, better communication among scientists, and a much wider audience interested in new approaches – but also some linguistic points that unite the authors. It would seem that early authors such as Fuchs and Vesalius were atypical. Seventeenth-century scientific authors' Latin seems to be more uniform: we might speak of academic Latin largely based on scholastic Latin but enriched with humanist and mathematical features; frequent Greek quotations can be counted among the former. Like scholastic Latin, this was a truly international form of communicating; regional peculiarities are hardly ever found. This academic Latin will remain in use up to the twentieth century in some cases (chap. 15). Its manifestations encountered in the text samples above may display a more Euclidean Latin (Newton) contrasting with a more scholastic type of writing (Leibniz). As touched upon already above (chap. 12 §2), in some sciences there is indeed a more marked change of style around the sixteenth century: toward a mathematical Euclidean Latin (see chap. 22). In some others, such as medicine, there is hardly any noticeable change (chap. 21). In fields in proximity to the humanists, a more pretentious style was now expected, for instance in philology and linguistics. Below (chap. 18), a text by the German philologist Heinrich Kretschmann (1844–after 1910) on Apuleius' Latin is used as an example of late philological academic Latin.

Comparison of Kircher and Newton

§6 From the foregoing, it will have become clear that in the seventeenth century several competing scientific approaches or paradigms coexisted and it was hardly clear which one would become the paradigm for the centuries to come: from mathematical theologies, rationalists, and hermeticists to experimentalist magicians, all treated in this and the previous chapters. Thus, the situation can be compared to that of the twelfth century: we can speak of different sub-*Denkstile*

65 See Olschki (1919–1927: 2:99).

(as the main scientific Greek approaches remained intact). Two of the main competitors can be compared using their most famous exponents: Kircher and Newton, who can be taken to stand for a more hermetic-holistic as opposed to a mathematical-empirical approach. The two men actually had much in common: both were interested in theology, human, and natural science, and both were seen as geniuses in their time. Kircher published in many fields, but Newton during his lifetime only in physics, where he had lasting success. For their approach to physics, a comparison between the *Principia mathematica* and Kircher's *Magnes sive de arte magnetica* (Romae, 1641) is illuminating. Kircher uses a similar structure as Newton: there are *experimenta*, *propositiones*, *theoremata*, *consectaria* (i.e. *corollaria*). But besides the occasional elementary geometry, there is no mathematical approach at all. In contrast, Newton made frequent use of geometry, occasionally hinting at calculus. Another obvious difference is that Kircher has a tendency to digress – for instance about thermometers, *thermoscopia* (586) – whereas Newton is more to the point; his magnum opus in its Euclidean terseness is, indeed, hard reading. Despite this very technical nature of Newton's text, the main idea, the three Newtonian laws of gravity, can be summarised on half a page. In his *Principia,* Newton speaks only about physics,[66] Kircher in his *Magnes* ends with a rather poetic digression on God as the ultimate magnet (*Deus opt. max. totius naturae magnes*; p. 907). This holistic approach may be typical of universalist 'hermetic' science. Wagner (2011: 12–16) compares what she calls 'hermetic' and 'mechanistic' worldviews that were competing in the sixteenth and seventeenth centuries: toward the end of this period, the latter clearly gets the upper hand; for this, Newton's *Principia* will have been crucial. Some of her distinctions can be summarised in the form of a table:

Topic	**Hermetic**	**Mechanistic**
matter	continuous, homogenic, featureless	atoms plus vacuum
(primary) qualities	exist in their own right; four elements, hot/cold	depend on atoms (thus, quality becomes quantitative)
causality	*magia naturalis* with sympathies	only through colliding atoms
nature	holistic: nature as organism, alive, divine, correspondence between different strata of being	nature as mechanical, not alive, not divine, only *made* by God, local interaction only

66 Excepting the famous *scholium generale*, first added to the work in the second edition of 1713 (https://www.e-rara.ch/zut/wihibe/content/titleinfo/338618). Here Newton discusses 'hypotheses' and theology. This text is short (481–484) and remains more an appendix than an integral part of the work itself.

This 'hermeticism' is largely based on neo-Platonism, which in turn had taken over Aristotelian methodology and terminology. The 'mechanistic' worldview is also indebted to Antiquity, especially Democritus and later atomists, but also Plato's *Timaeus*; the terminology is less Aristotelian, the rôle of mathematics and of Euclid is more central. Klein (2018: 211, shortened) has published a similar table but one that concentrates more on external factors. Kircher would still count among 'vormoderne Wissenschaft', Newton among 'moderne Wissenschaft':

	Vormoderne Wissenschaft (sprachfundiert)	**Moderne Wissenschaft (zahlenbasiert)**
Prototypischer Zugang	qualitativ-sprachlich (Substanzbegriff)	quantitativ-mathematisch (Funktionsbegriff)
Basiseinheit	Wort, Satz, Text	Zahl, Formel, Tabelle
Basisaktivität	lesen, schreiben, interpretieren	rechnen, messen, beobachten, experimentieren
Prototypischer Ort	Bibliothek, Lesesaal	Labor, Natur
Fakultäten/Leitdisziplin	Theologie, Medizin, Jura, Philologie	Naturwissenschaft (v. a. Physik, Chemie), Mathematik

Several traditional sciences had to undergo considerable adaptations in order to move from the former worldview to the latter and be integrated into the 'New Science'. Physics becomes quantitative, alchemy changes into chemistry,[67] astrology drops out completely. Positing two such types of science is conceptually interesting, but it should be kept in mind that most authors discussed above do not fit fully into one or the other: many of the protagonists of this paradigm shift in the natural sciences inhabited both worlds without reflecting on it at all. Newton the alchemist belongs to the former, Newton the physicist to the latter (although he does implement non-corpuscular 'force' with huge success).[68] And already in the eighteenth century, there were approaches that are hard to group into one of these two approaches, such as that of Boscovich, whose physical theory is based on an all-pervasive mathematical force that acts on point particles in varying strength depending on their distances, a theory that clearly grew out of

67 See Newman & Principe (1998), who point out that the two terms are synonymous before the eighteenth century. The important point here is that only the component of alchemy/chemistry that is compatible with the New Science remains as an acknowledged 'science'; it is eventually termed 'chemistry' in contrast to the rest ('alchemy').

68 More on Newton in this respect in Wagner (2011: part 3); Burtt (1954).

Newton's gravity yet contains elements of a 'hermetic' kind such as a holistic approach and its featureless point-atoms. Clearly, this dichotomy of old versus new science is only a rough template for a first look at reality that is more complex. In addition, it seems to have been confined to the natural sciences: although the revolutionary period brought many advances in the human, legal, and historical sciences (some mentioned in the list above), they were much more gradual and they do not fit into either of the tables.

Worse still, the victory of the mechanic worldview was not lasting. More and more features of what would seem to be typically 'hermetic' or universalist have returned to reputable sciences.[69] For instance, far distant systems can now be linked by 'quantum entaglement'. Traditional geometry, the key to science for Galileo and Newton, has in the meantime been transformed into the study of relations within mathematical groups.[70] It has moved very far fom Euclid, now studying things like the exactly seventeen wallpaper symmetry groups on the Euclidean plane (depicted in fig. 26);[71] this looks more like a Kircherian illustration than traditional Euclidean geometry. It would seem that a new revolution in the late nineteenth and in the twentieth centuries definitely reversed the victory of the mechanistic worldview, which was based on what is now seen as elementary Euclidean geometry. Today, even in physics the essential constituents are fields and forces that act at a distance, not atomic Lucretian corpuscles; the latter are seen as mere epiphenomena. It would seem that this Lucretian approach became so successful in the seventeenth century mainly due to the advances in mathematics, especially calculus, that enabled scientists to describe such phenomena quantitatively, something completely out of reach for Democritus or Lucretius. Although this mechanical atom-and-void approach made 'occult' interaction at a distance (important, for instance, in astrology) impossible, it proved to be too rigid: Newton's theory of gravity again introduces interaction at a distance, but with the important novelty that this interaction follows precise mathematical laws.

69 Of course, other things, such as the hot/cold qualities or the four elements, have been discarded for good by more advanced theories.

70 Especially by Felix Klein's Erlangen Programme; see Klein (1872).

71 Each of these patterns is invariant to some combination of Euclidean isometries (translations, rotations, reflections, and glide reflections). It was proved in 1891 that there are exactly seventeen such groups in the Euclidean plane.

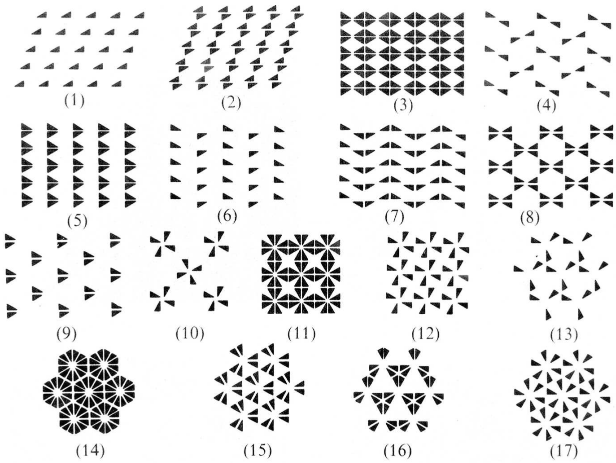


Fig. 26: The seventeen wallpaper groups, from Mainzer (1988: 151).

Since Kuhn it has become common knowledge that there is a revolutionary moment in science in general. For Latin science, the great revolution happens in the twelfth century with the advent of the Greek scientific *Denkstil* and the radical transformation of Roman and mediaeval science. That this change is not usually called a 'scientific revolution' will have to do with the fact that Latin science largely digested already existing Greek science during the twelfth century, in contrast to the seventeenth century, when completely new kinds of science developed. A final caveat about the validity of speaking of the Scientific Revolution seems necessary. After the so-called *Sattelzeit* (ca. 1750–1850)[72] that changed Europe, and with it the world, fundamentally, the greatest revolution in science started in the late nineteenth century and has not yet finished. This period stopped using Latin as a central vehicle for scientific communication (and is therefore outside the scope of this book) but has seen by far the greatest number of people working as professional scientists. Very important conceptual novelties have revolutionised many sciences and produced entirely new ones: some of the most important instances may be the concept of evolution in nature (famously with Charles Darwin, but also many others such as August Schleicher for language), new approaches to physics (quantum theory, relativity) and to mathematics (new foundations of set theory, including its paradoxes; chaotic systems), the invention of biochemistry, linking 'dead' and 'alive' matter, and the recent great advances in information theory. Statistical tools enable a new kind of pre-

72 This term is from Koselleck (1972).

cision for things that do not always behave the same way; they have recently produced the replication crisis (Ioannidis 2005). Together, these things have turned early eighteenth-century science as much upside down as it did Aristotelian science. Thus, the Scientific Revolution may have to be renamed the 'First Scientific Revolution'.[73]

Relation to criteria for science

§8 Although the 'Scientific Revolution' produced many different methods and approaches, there was definitely a general focus on methodology and on systematically searching out new phenomena in many fields (I and II). In the extreme case, in the mechanistic worldview only impacts between atoms were allowed as explanatory. Some things could be explained step-by-step very well, such as gravity (Newton) or blood circulation (Harvey). In this time, experimentation becomes central, and with it the criterion of testability is often more strongly satisfied than before (III). Some approaches (such as the mechanistic one) presented a coherent explanation for everything (IV). In these times, community efforts are also strengthened (V) and many sciences become more formalised, be it through mathematical (such as physics) or other means (such as Linnaeus' nomenclature of organisms; VI).

Thus, it will not come as much of a surprise that the criteria for science are well fulfilled in the age of the 'Scientific Revolution'. Of course, appropriate methodology was much discussed, and much of it has been changed in the meantime: for instance, no one today shares a purely mechanistic worldview any more. However, as already hinted at, the demarcation between 'Scientific Revolution' science, hermeticist science, neo-Platonist science, and other forms of trying to reach insight was not at all clear at the time. It only seems clear to us in retrospect, and quite an amount of hagiography has been produced for some of the most important exponents of the 'Revolution', such as Galileo and Newton. We have seen (§3) that even Newton lived in at least three intellectual worlds: those of the physicist, the (heretical) theologian, and the hermeticist alchemist. More or less at the same time, both the 'Scientific Revolution' and the general international use of Latin in science and scholarship come to a close in the eighteenth century. The next chapter describes this process and will then try to find some reasons for why it happened, and why it happened then.

73 Vol. 8 of the Petruccioli (2001–2004) encyclopaedia, indeed, aptly bears the title *La seconda rivoluzione scientifica* for this time.

14 The demise of Latin as language of science

> von einer unverzichtbaren Gemeinsprache zu einem schmückenden Bildungsattribut und schließlich zu einem Anachronismus.
> 'from an indispensable common language to a decorative educational attribute and finally to an anachronism'.
>
> Korenjak (2016: 102)

§1 The chronological tour of authors and *Denkstile* in the preceding chapters will now be broken off: from the eighteenth century onward, most important authors no longer wrote in Latin. A comprehensive study of the circumstances of Latin's demise in the sciences and at the universities has yet to be written.[1] Only selected aspects of a topic that has only been studied for single cases can be presented here, with the goal of finding the major driving forces that led to the use of vernacular tongues in fields where Latin had been the only option for more than a millennium.[2] At the advent of the printing press, Latin still had a very comfortable lead as the written language of Western Europe. 70 % of all incunabula were written in Latin.[3] First, Latin's demise in different contexts is studied (§2); some problems of the change of linguistic medium, which led to a group of three languages taking over Latin's rôle, are then discussed (§3); some reasons for this change are considered (§§4–8); and finally, an excursus on artificial languages (§10), a topic that became important precisely when Latin's hegemony was broken, concludes this chapter.

§2 The transition away from Latin happened at a varying pace in different fields. Broadly speaking, the more supraregional and theoretical the subject matter, the longer Latin remained its medium.[4] Literature on practical *artes* that had to be understandable to people who had not studied at universities sometimes already tended to be written in the vernacular in the sixteenth century (see the list below), and quite universally in the seventeenth century, whereas theoretical scientific works were nearly universally written in Latin until the first half of the eighteenth century. Knowledge of Latin was still necessary in most sciences up to at least 1800.[5] In some branches, such as law, theology, and classical philology, Latin was still the norm in the nineteenth century and occasionally still in use in the

1 See Ogilvie (2015: 273–275).
2 Leonhardt (2013) speaks of a 'Latin millennium' (title of chap. 3).
3 See Korenjak (2016: 18). The next-most-often-used languages were German (10.8 %), Italian (8 %), and French (5.7 %); all others were below 2 %.
4 See table in Schiewe (1996: 102). See also Leonhardt (2009/2010).
5 Thus Leonhardt (2013: 197).

https://doi.org/10.1515/9783110745832-015

twentieth (see chap. 15 below).[6] The numbers of scientific book publications at the book fair in Leipzig from 1740 to 1800 are very telling. Whereas the total numbers of books rise very strongly from 12 to 129 publications in the natural sciences, the percentage of Latin plummets: in 1740 the Latin:German ratio is 8:4; in 1800 it is 21:108.[7] Similar dates were observed in another study by Pörksen; he studied the extensive collection of scientific (including natural-scientific, mathematical, and medical) books from the Herzog August Bibliothek (Wolfenbüttel) and published the graphic reprinted as figure 27. It is in the 1770s that the general amount of books 'explodes', most of them being German ones.[8] Hardly surprisingly, the second half of the eighteenth century sees many theoretical publications for or against the use of Latin in science and education, for instance Bernhard Stöger, *Über die Frage: Welcher Lehrvortrag in der Philosophie ist auf deutschen Universitäten der nützlichere: Der lateinische od. der deutsche?* ('On the Question: Which Lecture Language in Philosophy Is More Useful at German Universities: Latin or German?'; Salzburg, 1790),[9] who opts for German, and the response, over twice as long, by the Benedictine Aemilian Würth, *Frage: Welcher Lehrvortrag in der Philosophie der nützlichere?* ('Question: Which Lecture Language in Philosophy Is the More Useful?'; Augsburg, 1793).[10] Stöger argues that the Germans should follow the French and English and use their native tongue, while Würth stresses Latin's precision and stability, but, tellingly, writes in German too.

In many other fields and regions, Latin had already lost its hegemony in the sixteenth century; for instance, poets in France change from predominantly Latin to predominantly French toward the end of the sixteenth century.[11] The general situation on the book market is similar in France: French already overtook Latin around 1560, after which Latin stayed at around a quarter of French book publications for the next century. Similar changes happen in Italy only nearly a century later.[12] Things were, however, different in matters of science and learning, where international communication was vital and a precise linguistic vehicle was needed. In the middle of the seventeenth century, Blaise Pascal still changes to Latin as soon as he talks about scientific matters (here on combinatorics to Fermat, letter from 29 July 1654, ed. in About 1983: 41): 'Par exemple, et je vous le dirai en latin, car le français n'y vaut rien: Si quotlibet litterarum, verbi gratia octo

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6 The rôle of language at German universities is studied by Schiewe (1996: 80–115).
7 As can be seen from the table in Pörksen (1986: 50).
8 A similar date is confirmed by Waquet (1998: 113–114).
9 Online at http://mdz-nbn-resolving.de/urn:nbn:de:bvb:12-bsb10840617-0.
10 Online at http://mdz-nbn-resolving.de/urn:nbn:de:bvb:12-bsb10047374-7.
11 See statistics in Ford (2013: chap. 1).
12 Numbers collected in Waquet (1998: 102–103).

[...]' ('For example, and I'll tell you this in Latin, because French is no good for it: *Si quotlibet litterarum, verbi gratia octo* [...]').

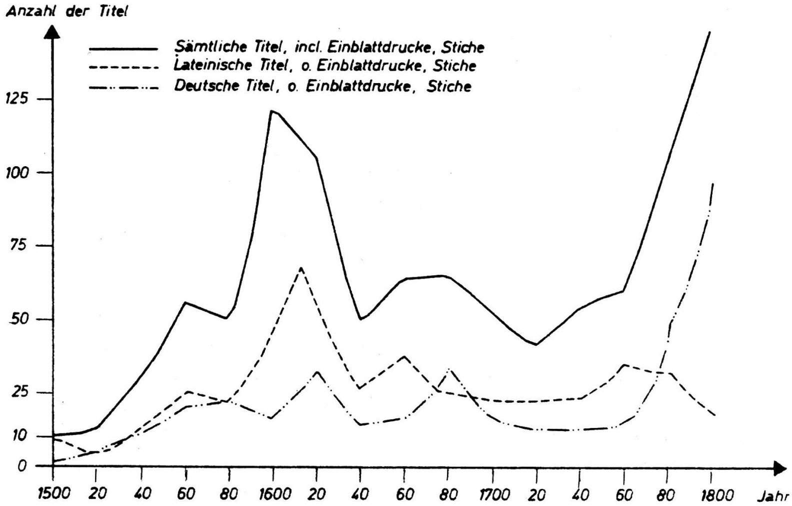

Fig. 27: Latin vs German books at twenty-year intervals in the Wolfenbüttel library. A definite trend against Latin does not begin until 1770. Source: Pörksen (1986: 55).

A century later, in 1765, Latin was still perceived as *the* international language of erudition by Diderot's *Encyclopédie*, even though the work is written in French (Diderot, s.v. *langue*):[13]

> La langue latine est d'une nécessité indispensable, c'est celle de l'église catholique, & de toutes les écoles de la chrétienté, tant pour la Philosophie & la Théologie, que pour la Jurisprudence & la Médecine: c'est d'ailleurs, & pour cette raison même, la langue commune de tous les savans de l'Europe, & dont il seroit à souhaiter peut-être que l'usage devint encore plus général & plus étendu, afin de faciliter davantage la communication des lumieres respectives des diverses nations qui cultivent aujourd'hui les sciences: car combien d'ouvrages excellens en tous genres de la connoissance desquels on est privé, faute d'entendre les langues dans lesquelles ils sont écrits?
> 'The Latin language is an indispensable necessity: it is the language of the Catholic Church, and of all schools of Christianity, as much for philosophy and theology as for jurisprudence and medicine. It is, moreover, and for this very reason, the common language of all scholars of Europe, the use of which it is perhaps to be hoped will become even more general and more widespread, in order to facilitate further the communication of the respective luminaries of the various nations which today cultivate the sciences. For how many excellent

13 Further similar statements from all over Europe in the eighteenth century can be found in Waquet (1998: 101–102).

> works of all kinds are there of whose acquaintance one is deprived for lack of understanding the languages in which they are written?'

The standard work on Latin's use in early modern society (especially but not only in France) is Françoise Waquet's *Le latin ou l'empire d'un signe* (1998). She shows in the first part in a very detailed manner how the rôle Latin played in school curricula started to change in the seventeenth century – for the first time allowing space for the mother tongue, here French, to be taught and studied – and around the middle of the eighteenth century, when Latin stopped being the most important subject in many schools. Of course, Latin had been taught actively and passively, and in most schools up to that time pupils were supposed to speak Latin not only in class but also with one another. This background makes it easy to estimate that active command of the Latin language was a matter of course for educated people up to the eighteenth century – at least as much as is now the case for English among non-native natural scientists. The emphasis put on Latin in higher schools fluctuated in the eighteenth and nineteenth centuries but generally remained high. It was only in 1882 that a *baccalauréat* without Latin became possible for the first time (Waquet 1998: 25). Nevertheless, there seems to have been a growing gap between school Latin and 'real life', such that in the eighteenth and nineteenth centuries most important scientific contributions were already published in the vernacular. Before the opening of this gap, difficulties in the active use of Latin could only be an obstacle for people who had not studied at a 'decent' school (such as some technical writers from artisan families); other people who instead chose to use their vernacular for publications will have done so for other reasons. A short list of some early vernacular scientific publications may help to identify motivations.

- (Alternative) medicine: Theophrastus Paracelsus, German inaugural lecture in Basle, 1528 (caused a stir).[14]
- Ballistics: Niccolò Tartaglia, *La nova scientia* (Vinegia [Venice], 1537), in Italian. The new science is ballistics; the treatise is mostly concerned with practical applications.
- Mathematics: Simon Stevinus, *De Thiende* ('On Decimal Fractions'; Leyden, 1585), in Dutch. Stevinus was convinced that Dutch was most suited for science and invented many Dutch scientific terms.[15]

14 Anti-humanism and an alternative, not tradition-bound approach to medicine seem to have been his reasons for doing this. See Pörksen (1994a); for his biography, still Rádl (1913).
15 See Vanden Berghe et al. (2004).

- Heliocentricism: Galileo Galilei, *Dialogo sopra i due massimi sistemi del mondo* (Fiorenza, 1632), in Italian. Intended for a wider Italian public.
- Scientific methodology: René Descartes, *Discours de la méthode pour bien conduire sa raison et chercher la vérité dans les sciences* (La Haye, 1637), in French.
- Foundation of the Royal Society of London for Improving Natural Knowledge in 1660. It published mostly in English.[16]
- Microbiology: Robert Hooke, *Micrographia* (London, 1665), in English. Discovery of microorganisms.
- Chemistry: Robert Boyle, *The Sceptical Chymist* (London, 1666), in English. Foundation of modern chemistry.
- Foundation of the Académie royale des sciences in 1666, publishing mostly in French.
- The jurist Christian Thomasius starts to lecture in German in Leipzig in 1687.
- Optics: Isaac Newton, *Opticks* (London, 1704), in English, in contrast to his *Principia*, first published in Latin.[17] But the second edition was published in Latin as *Optice* (Londini, 1706).

It was in the time around 1660 that scientific institutions such as the Royal Society or the Académie royale, which often published in their vernaculars, were established for the first time.[18] Interestingly, the Royal Society excluded human sciences and theology in order not to get caught up in Reformation quarrels. It is tempting to see this as the germ of the later special development of the English term 'science' as applying only to the natural sciences (as discussed in chap. 1), although this may be oversimplifying things – at any rate, similar societies on the Continent worked in both natural and human sciences.

On the whole, it would seem that Latin retained a near-monopoly in science until the first quarter of the seventeenth century. Many of the early works in the list above were more of practical or regional interest. A list of crucial scientific works in French in the eighteenth century would certainly be longer than a corresponding one of Latin ones. Nonetheless, for the rest of the seventeenth and the beginning of the eighteenth century important works of more than regional interest tended to be translated into Latin quickly and had often greater success in Lat-

16 In contrast, the *Acta eruditorum* (Leipzig) were published in Latin until 1776: http://www.izwtalt.uni-wuppertal.de/Acta.html.

17 For a more extensive list of authors and their publication languages, see Pörksen (1986: 60–61).

18 The importance of these societies for the new kind of modern science has often been stressed, e.g. by Teich (2015: 54–63).

in with an international audience.[19] The scientific journals can be seen as a foreboding of Latin's eventual demise as the international language of learning. But at first there were sometimes (unofficial) Latin translations, for example for the Royal Society's *Philosophical Transactions*.[20] Most French scientists in the later seventeenth century already published exclusively in French (e.g. Edme Mariotte, Bernard Le Bovier de Fontenelle; René Descartes, Blaise Pascal for the greater part), whereas in English this would only be the case in the eighteenth century (Stephen Hales, John Priestly) and in German around its middle, as can be seen from the graphic above. In Italian, Galileo and Bruno are better seen as exceptions with their early use of the vernacular, and their intention was polemical: they wanted to reach a larger, not only academic, audience within Italy. They both published their more scientific or technical works in Latin.

It will have become clear by now that the trend that led to Latin's replacement originated in France in the later seventeenth century. The reason for the French language's success would seem to be its new ideals and its function as a rôle model for style, which led to French becoming the international language[21] in many other areas around the same time, most prominently in diplomacy: the Treaty of Rastatt (1714) was in French only and can be seen as the definite turning point. In 1698 Jean-Baptiste du Hamel still used Latin because[22]

> *linguam Gallicam non esse tam late fusam quam Latinam, quae ubique gentium eadem est, neque tot mutationibus obnoxia, quot linguae vulgares.*
> 'the French language is not as widely used as the Latin one, which is the same for all peoples and is not prone to as many changes as the vulgar tongues'.

By 1751 the outcome had become clear, and D'Alembert concedes:[23]

> L'usage de tout écrire aujourd'hui en langue vulgaire, a contribué sans doute à fortifier ce préjugé, et peut-être est plus pernicieux que le préjugé même. Notre langue s'étant répandue par toute l'Europe, nous avons cru qu'il était temps de la substituer à la langue latine, qui,

19 For instance, Immanuel Kant's critiques were quickly translated by Friedrich Gottlob Born as *Opera ad philosophiam criticam*, 3 vols (Lipsiae, 1796–1798). For more examples, see Waquet (1998: 108–109).
20 See Korenjak (2016: 239).
21 See Fumaroli (2003), who presents examples of non-French authors writing in French between 1714 and 1814. Disappointingly, his 'livre n'a pas la moindre prétention de théoriser, ni de défendre une thèse quelconque' ('book does not claim to theorise or defend any thesis whatsoever'; 24).
22 *Regiae Scientiarum Academiae historia* (Paris: Etienne Michalet, 1698), unpaginated preface. Quoted from Gordin (2015b: 42).
23 D'Alembert ([1751] 1911), http://art-bin.com/art/oalembert2.html.

depuis la renaissance des lettres, était celle de nos savants. [...] Cependant il résulte de là un inconvénient que nous aurions dû prévoir. Les savants des autres nations, à qui nous avons donné l'exemple, ont cru avec raison qu'ils écriraient encore mieux dans leur langue que dans la nôtre. L'Angleterre nous a donc imités; l'Allemagne où le latin semblait s'être réfugié, commence insensiblement à en perdre l'usage; je ne doute pas qu'elle ne soit bientôt suivie par les Suédois, les Danois et les Russes. Ainsi, avant la fin du dix-huitième siècle, un philosophe qui voudra s'instruire à fond des découvertes de ses prédécesseurs, sera contraint de charger sa mémoire de sept à huit langues différentes, et, après avoir consumé à les apprendre le temps le plus précieux de sa vie, il mourra avant de commencer à s'instruire. L'usage de la langue latine, dont nous avons fait voir le ridicule dans les matières de goût, ne pourrait être que très utile dans les ouvrages de philosophie dont la clarté et la précision doivent faire tout le mérite et qui n'ont besoin que d'une langue universelle et de convention. Il serait donc à souhaiter qu'on rétablît cet usage; mais il n'y a pas lieu de l'espérer.
'The practice of writing everything today in the vernacular has undoubtedly contributed to strengthening this prejudice, and is perhaps more pernicious than the prejudice itself. As our language [French] has spread throughout Europe, we thought it was time to replace the Latin language with it, which, since the renaissance of letters, had been the language of our scholars. [...] However, this produces a disadvantage that we should have foreseen. The scholars of other nations, to whom we set an example, rightly believed that they would write even better in their own language than in ours. England has therefore imitated us; Germany, where Latin seemed to have taken refuge, is slowly beginning to lose the use of it. I have no doubt that it will soon be followed by the Swedes, the Danes, and the Russians. Thus, before the end of the eighteenth century, a philosopher who wants to learn in depth the discoveries of his predecessors will be forced to load his memory with seven or eight different languages, and, having spent the most precious time of his life learning them, he will die before he begins to learn their philosophy. The use of the Latin language, the ridiculousness of which we have shown in matters of taste [i.e. in the belles-lettres], could only be very useful in works of philosophy, where clarity and precision must take all the credit, and which only require a universal and conventional language. It would therefore be to be wished that this use would be re-established, but there is no reason for hope.'

This is quite a surprising and far-sighted confession by the author of a huge and very influential encyclopaedia written in French, not in Latin. Others, such as Pierre Louis de Maupertuis, tried to devise schemes to return to a Latin using European elites (de Maupertuis 1752: 57–58):

Il ne faudroit que confiner dans une même Ville, tout le Latin de son Païs; ordonner qu'on ny prechât, qu'on n'y plaidât, qu'on n'y jouât la Comedie qu'en Latin. Je crois bien que le Latin qu'on y parleroit ne seroit pas celui de la Cour d'Auguste, mais aussi ce ne seroit pas celui des Polonois. Et la jeunesse qui viendroit de bien des Païs de l'Europe dans cette Ville, y apprendroit dans un an plus de Latin qu'elle n'en apprend dans cinq ou six ans dans les Collèges.
'One would only have to confine in the same city all the Latin of one's country; to order that there people preach, plead, and play the comedy exclusively in Latin. I well believe that the Latin spoken there would not be the Latin of the court of Augustus, but it would also not be

> the Latin of the Poles. And the youth who'd come from many countries of Europe to this city would learn more Latin in a year's time than they learn in five or six years' time in the colleges.'

But most less far-sighted compatriots of D'Alembert and Maupertuis did not see the problem, and conferred immortality on the most perfect French language (see §6 below).

The list at the beginning of the next chapter will show that Latin still played an important rôle in the sciences in countries beyond the direct influence of French, English, and German all through the eighteenth and well into the nineteenth century. Then, some writers start to complain both about French as the new language of science, such as Johann Rudolf Kiesling, who in 1752 called it a *morbus epidemicus*,[24] and the problem that scientists will have to learn many languages without the unifying Latin: like D'Alembert, Albrecht von Haller bemoans that it will be necessary to learn 'six or eight' languages.[25]

§3 The actual linguistic transition from Latin to the vernacular languages was, of course, easiest for the Romance languages. The French could and very often did just change a term's ending and pronounced it as if it was a proper French word.[26] The fact that French is syntactically less versatile than Latin will not have been too great a problem: instead of, say, an *ablativus absolutus*, a subordinate clause might do. The same is true for Italian and largely also for English, which had already become a kind of Germanic-Romance creole in Middle English times. But in the case of German, things were rather more complicated. The language belongs to a different branch of the Indo-European family from Latin, and Germans were not very fond of using foreign terminology. Therefore, many new terms had to be invented. Incidentally, this may also be part of the reason why the transition to the vernacular in science happened later in German. Gottfried Wilhelm Leibniz (1646–1716) and Christian Wolff (1679–1754)[27] were the most important men in defining the German philosophical and general scientific terminology, which had to

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24 Kiesling, *Commentatio*. Full quotation: *Invaluit nostro saeculo morbus, ut rei medicae doctores loqui amant, epidemicus, quo linguae imprimis Gallicae usus eruditis maxime sit familiaris* ('In our century, an epidemic disease has grown strong – as the medical doctors choose to call it – by which first of all the use of the French language has become most familiar to scholars'; quoted from Sacré 2014: 18–19).

25 Krebs (2005: 368). More examples can be found in Sacré (2014).

26 Examples in the list in chap. 23 §3 below.

27 See Baumeister, *Philosophia definitiva*, a lexicon of Wolff's Latin terminology; and for his German terminology Meissner (1737).

correspond to the existing Latin terminology. Indeed, Wolff (1734) usually offers a Latin translation in his lexicon of German mathematical terms, such as 'Abschnitts-Winkel, *Angulus segmenti*' (8) to make himself understood. In his *Vernünfftige Gedancken von Gott* (1738), he even offers a German–Latin glossary[28] of German terms he chose to use for widespread philosophical concepts. Many of these expressions stuck in the German language, but some others did not, as some random examples show:

Vernunfft: *ratio*,
Versuche: *experimenta*,
Vor sich bestehendes Ding: *substantia*,
Zufällige Namen: *adjectiva*.

Despite such preparatory work, the rôle of Latin remained important in Germany throughout the eighteenth and nineteenth centuries: the German gymnasium grew out of the *Philanthropinismus* and *Humanismus* movements, which were at odds in many things but agreed in stressing the importance of Latin, the former more its actual use and the latter more for reading the classics. In a ten-year plan for weekly teaching at the gymnasium from 1816,[29] Latin is still by far the most extensively taught subject: on average 7.6 hours per week (German only 4.4, Greek 5, mathematics 6). In the 1882 *Lehrplan* by Hermann Bonitz,[30] Latin even reached an average of 8.2 hours per week; German was down to 2.3, mathematics to 3.7, and Greek to 4.4.[31] At this time, there were already reformers who strove to abolish Latin composition from the curriculum, but they only succeeded in 1892.[32] By 1925 Latin had lost its hegemony; in 1938 – in the Third Reich, the Nazis obviously preferring German over Latin – it became close to irrelevant. Despite this slow development, German already became an important vehicle for science in the early nineteenth century. Indeed, English and German followed the French trend and were in the eighteenth and nineteenth centuries able to end the brief sole hegemony of French both in the sciences and in society at large. Throughout this time, French, German, and English remain the three languages of science.[33] In some fields, for instance in classical studies, this situation remains relatively un-

28 On the five unpaginated pages after p. 672. The first edition (1724) did not contain this appendix.
29 Numbers from Fuhrmann (2001: 149).
30 The same Bonitz who authored the still-indispensable *Index Aristotelicus*.
31 The Gymnasium was now a nine-year course, at the beginning of the century a ten-year course. Figures from Fuhrmann (2001: 174).
32 Fuhrmann (2001: 219).
33 The 'triumvirate', as Gordin calls this constellation.

challenged to this day (including Italian as a fourth option). As D'Alembert had predicted, by the later nineteenth century, several other languages aspired to become part of the illustrious group of 'scientific languages'; the case of Russian and its difficult and ultimately successful struggle to reach this goal is described admirably by Gordin (2015b: chaps 2–3). Indeed, the only distantly related Russian language had to adapt and standardise in a very similar way to German when taking over the rôle of Latin, and to Latin when taking over the rôle of Greek. Scientific Russian borrowed much from the then leading German (as did the Russian language in general). Some considerations of this language's structure will be presented in chapter 23 in comparison to others. Other languages, excepting further Romance ones such as Spanish, and possibly Japanese, have had at best very limited success so far.

It may be attributed to the events around the two World Wars that English started to take on the rôle of the sole language of science. Savory wrote in 1953: 'English shows signs of becoming the language of science' (153). Around the same time, the arachnologist Reginald F. Lawrence made a survey of the languages used in the *Zoological Record* from 1865 onward.[34] English, French, and German, followed by Spanish and Russian, together made up about 90 % of all publications. Toward the end of the period studied by him, English started to rise sharply and only Spanish was able to hold its ground. In the last few decades, it seems that at least in natural science we are again approaching a time of monolingualism, in this case one of English. The reasons for this change are clearly political: the victory of the US and the UK in World War II, and more recently the fall of the Soviet Union. It remains to be seen for how long this situation will remain stable in a world of a booming Asia and a stagnating West. But returning to the question of the reasons for Latin being supplanted in the eighteenth century, a few arguments will now be considered, often already used by contemporaries, and weighed in their importance.

(i) Novelty and adaptability

§4 In some cases, a conscious effort not to be part of the scholastic establishment can be sensed. This seems especially obvious among the Italian authors of the sixteenth and early seventeenth century. Christian Thomasius can be mentioned as a later example; he wanted to part with the use of Latin in order to get rid of old-fashioned ways of thinking and the influence of *Pfaffen* (pejorative German term

34 *Non vidi*; discussed in Savory (1953: 155–157).

for priests).[35] But this reason was certainly not the main one for the development away from Latin; in fact, scientists quite often complain to one another that they cannot read one another's vernacular publications (such as Kepler to Galileo; see chap. 13 §4). The Latin language proved itself to be quite adaptable to new ideas of scholasticism, although classicising humanists who got the upper hand at the *gymnasia* did their best to petrify the language. Thus one had to choose between a versatile but 'ugly' Latin (the type mostly used) and a beautiful but hardly adaptable and hard to learn variant of the same language (advocated by Ciceronians from at least the fifteenth century onward). The downside of the flexibility of the vulgar tongues is, of course, that they change fast. Even a German native speaker today will find Kant's German difficult and unfamiliar, whereas a Latin reader will move with comparative linguistic ease through the centuries. This will be elaborated below (chap. 16). The following topic is related to it.

(ii) Ease of expression

§5 One might also argue that new concepts are more easily expressed in one's native language and not a long-'dead' (see chap. 16 §1 below) one, an argument often heard in Romanticism. It has, however, already been mentioned that this argument holds true only for people who did not enjoy a thorough education: up to the later nineteenth century, gymnasia were so much focused on Latin that this language will have become like a second native tongue to students. The forgotten world of Latin Jesuit schools in the twentieth century will be discussed below; they will confirm that fluency in Latin cannot have been a problem for scientists who had attended higher education in the centuries before. Yet this faulty argument was very commonly used against Latin in the eighteenth century, for instance by Voltaire, who states in his *éloge* for the recently deceased Émilie du Chastelet, the French translator of Newton's *Principia* (Voltaire 1752: 141):

> Le français qui est la langue courante de l'Europe, & qui s'est enrichi de toutes ces expressions nouvelles & nécessaires, est beaucoup plus propre que le latin à répandre dans le monde toutes ces connaissances nouvelles.
> 'French, which is the common language of Europe, and which has been enriched with all these new and necessary expressions, is much more appropriate than Latin for spreading all this new knowledge throughout the world.'

The preceding paragraph, and the fact that scholastics had expressed completely new and rich ideas with ease in Latin for centuries, will be enough to convince the

35 Examples are given in von Düffel's edition (= Thomasius 1970).

reader that Voltaire is here merely voicing propaganda for the glorious and immortal French language. This leads us to political aspects, which are certainly much more crucial in the demise of Latin.

(iii) Nationalism and hegemonic politics

§6 The two points just mentioned suggest that it was more a matter of will than of ability which language, the vernacular or the international Latin, was chosen, especially if the vernacular was not too different from the standard language (as in Romance and English), so Latin can be used as a quarry as well as the other way round. Some political changes were favourable for the spread of the use of French in this time. The cancellation of the Edict of Nantes (1685) forced French Protestants to emigrate – together with their language. The outcome of the War of the Spanish Succession (1701–1714) brought a strengthening of France and a weakening of her main competitors (especially the Netherlands, Spain, and Germany). Thus, Englishmen, Germans, and Dutchmen were in general more proficient in French than vice versa around 1700. That the final breakthrough for the French language happened only after the War of the Spanish Succession can be guessed from the fact that Newton's *Opticks* were quickly translated into Latin in 1706, but into French only in 1720. By then there was a clear feeling among French intellectuals that their language was superior to others. Below (chap. 24 §4), a few examples show that such feelings regarding the superiority of one's own language were common also outside of France. The difference with French is that the rest of Europe gradually started to agree; thus, the German Christian Thomasius praises the new French lifestyle, which was quickly becoming the rôle model toward the end of the seventeenth century with its concepts of *honnêteté*, *bel esprit, bon goût,* and *galanterie*.[36] Frederick II's Königlich-Preußische Akademie der Wissenschaften, located in Berlin, published exclusively in French during the time de Maupertuis led it (1746–1759).[37] The Berlin academy ran a competition in 1783 on the question: 'Qu'est-ce qui a rendu la langue Française universelle? Pourquoi mérite-t-elle cette prérogative? Est-il à présumer qu'elle la conserve?' ('What made the French language universal? Why does it deserve this prerogative? Is it likely to retain it?'). The winner, de Rivarol, produced 'insights' of the following kind: 'Ce qui n'est pas clair n'est pas français; ce qui n'est pas clair est encore anglais, italien, grec ou latin' ('What is not clear is not French; what is not clear is still English, Italian, Greek, or Latin'; [1784] 1991: 27). His answers to the questions are,

36 Thomasius (1970: 45).
37 For this paragraph, see Terrall (2017).

in short, 'because of its inherent superiority' (for the first two) and 'yes' (third question).[38] This fanatic French nationalism could, of course, not go unanswered. Soon the English and then the Germans entered the struggle for the leading language in Europe in general and thus also for the sciences. As a 'triumvirate', all three languages were important throughout the nineteenth century. After the World Wars, it was the American lifestyle that became similarly 'in', 'hip', and 'cool' in Europe, and since then there has been a steady growth in the percentage of scientific communication in English.

After a language attains a certain hegemony, it is mere pragmatism on the part of authors to make use of the leading language; nationalism is no longer a key component. But initially, nationalism was certainly one of the strongest forces in the choice of scientific language; it was strongly opposed to the shared Latin in the eighteenth century – not only in France, but the French won the battle for the new international language, at least for a few decades. Once the age of nationalism had commenced, changes in the language of university communication became purely politically based, and a reduction of student mobility followed suit.[39]

(iv) Formalisation

§7 As has been shown, the New Science entailed more mathematics and formalisation in general and, on the other hand, an attempt to depend less on specific languages,[40] which in turn makes scientific insight less dependent on the language it was first expressed in. We have seen (chap. 13 §4) that for Galileo geometry is the language of God, not Hebrew, Greek, or Latin, the 'holy' languages of the Middle Ages and early modernity.[41] This thought is developed further by Étienne Bonnot de Condillac (1714–1780), whose famous dictum is: 'la science est une langue bien faite' ('science is a well-made language'; 1798: 7). Unlike for de Rivarol,

38 Speaking of the European empires and monarchies of his day, de Rivarol claims: 'On ne peut en prévoir la fin, et cependant la langue française doit encore lui survivre' ('One cannot foresee their end, and yet the French language will still have to survive them'; 1784: 38). This was about a decade before the French Revolution! In fact, Rivarol can be seen as a prime example of decadent and arrogant French intellectuals before the Revolution.

39 Summary and further literature in Prinz (2019).

40 See Ulbrich (2009/2010).

41 Isidore, *Etymologiae* IX.1.3, ed. Reydellet, p. 33, says: *Tres sunt autem linguae sacrae: hebrea, greca, latina, quae toto orbe maxime excellunt. His enim tribus linguis super crucem Domini a Pilato fuit causa eius scripta* ('There are three sacred languages: Hebrew, Greek, Latin, which excel in the whole world. For on the Lord's Cross His cause [of being executed] was written by Pilate in these three languages'). This is often quoted by later authors.

such a language is not French – perfect by its divine nature – but formalised, mathematical language. Condillac's prime example is algebra and mathematical formalism in general. Will such a well-made language, then, abolish Latin? It is certainly incorrect to claim that 'the main victim of the Scientific Revolution of the 16th and 17th centuries is without doubt the Latin language and its (quasi)monopoly as the language of academic scientific teaching and publication',[42] as will have become evident by looking at the major works of this Scientific Revolution and their language in the list above. But the increasing formalisation seems to be the deeper reason making such a statement understandable. These Latin-writing scientists and their more formal approaches eased the way to switch languages.

Indeed, students of most natural sciences today need to learn new formal languages that are no one's native tongue. They all use their own specific systems of symbolic notation. Since the time of much greater and conscious formalisation in the seventeenth century, the importance of the accompanying language has gradually diminished. Modern mathematicians without a common language, I am told by colleagues, are able to 'talk' about mathematics at quite a high level simply using formulas. Other obvious modern examples of such very successful formalised notations would be modern chemistry or logic. Typical modern scientific 'statements' may look like this:[43]

$$f(z) = \sum_{k=0}^{n} a_k \cdot z^k = a_n \cdot \prod_{i=1}^{n} (z - z_i) \text{ in } \mathbb{C} \quad \textit{or} \quad \mathrm{NaCl} + \mathrm{H_2O} \rightarrow \mathrm{HCl(aq)} + \mathrm{NaOH(aq)}$$

Both these statements could also be formulated in a long and complicated sentence in human language, but the formulas are much more concise and succinct for the specialist. The task of the natural languages used in such highly formalised sciences is now much simpler: they mainly explain the constituents of the formulas which are at the core. The roots of this trend of formalisation are, however, much older than the seventeenth century, at least in mathematics. For instance, the first use of our familiar symbols for elementary algebraic operations (+, −, ×, ÷) occurs among Italian mathematicians in the fifteenth century.[44] Formalisation proceeded – and proceeds – at very different paces in different scientific fields.

Another, much more recent example of how all of a sudden there can be a solution to formalising something that had posed linguistic problems for a long time

42 As claimed by IJsewijn (1990–1998: 2:324).

43 Representing, respectively, the fundamental theorem of algebra and the solution of common salt in water.

44 See Cajori (1928–1930); Wolfram (2000).

are names of colours. Below (chap. 21 §3), it will be seen that medical authors used unusual colour adjectives in Latin, apparently because the usual ones did not seem to be sufficiently precise. Only in Internet times has a consensus been formed to use hexadecimal codes to identify colours: two hexadecimal numbers each indicating the red, green, and blue content of a colour. Thus, instead of a hard-to-translate term such as 'medium aquamarine', one can now identify this colour as '#66CDAA'. Over sixteen million colours can be defined in this way, something no natural language would be able to do. In order to visualise the quoted colour, for instance, it suffices to enter the code in Google search or in software such as GIMP.

Other, mostly human, sciences have not become strongly formalised and are still much more dependent on the language their texts are written in.[45] Of course, in any science, there will always remain parts that are not formalised and have to be communicated in 'enhanced' natural language. Even for the formulas quoted above, someone has to tell you in human language what, for instance, 'HCl' means.

(v) Illustrations and other extra-linguistic devices

§8 First evidence of scientific illustrations can already be found in Aristotle, *De caelo*.[46] Another illustrated work, a kind of anatomy atlas (Περὶ ἀνατομῶν) of his, is unfortunately lost. The important rôle of the diagrams in Euclid's *Elementa* will be seen below (chap. 22 §4). Other symbolic letter systems already evolved in Hellenistic times, such as the symbols used in textual criticism or music;[47] in other sciences such as astronomy and geography, maps were of great importance,[48] and herbals also often depicted the plants they treated. The Vienna Dioscurides from ca. AD 515 is the only complete illustrated scientific manuscript from Antiquity that is still extant (fig. 28). Such manuscripts were certainly not too rare in Antiquity. However, in the history of transmission, such extra-linguistic devices tended to suffer more easily, as scribes were not familiar with them. Illustrations

45 Chap. 22 below will contrast a natural and a human science and their relation to language, with some examples.

46 Stückelberger (1994: 12–16), with reproductions from Aristotle manuscripts. On scientific illustrations, see Weitzmann (1959), and more recently Lazaris (2017) for Byzantine scientific and technical manuscripts. Lazaris is preparing a similar study for Latin manuscripts. For the time between Boethius and Lullus, see Guerrini (2016), including reproductions of many examples.

47 See Netz (1999: 61), with further references; for examples of (now lost) illustrations from Aristotle, see Fögen (2009: 53).

48 Cf. the colour plates in Stückelberger (1994: after 72).

may have been quite frequent in books in Antiquity but through copying often suffered heavy change, or may have been left off completely, such as the sketches originally included in Vitruvius. Euclid's *Elementa* are an exception insofar as the diagrams were an indispensable part of the text and were copied in an amazingly uniform way in most manuscripts. In general, diagrams are not rare and are important in many fields in the Middle Ages, both scientific and otherwise.[49]

Fig. 28: The Vienna Dioscurides in Greek, Wien, ÖNB, Cod. med. gr. 1, fol. 167v, showing *Cannabis sativa*. The Arabic gloss reads *qinnab bustāni* ('garden hemp').
Source: https://commons.wikimedia.org/wiki/File:Cannabissativadior.jpg (image by user Nina-no, public domain).

The advent of the printing press was a great change for such extra-linguistic communication between author and reader.[50] Only a few years after Gutenberg's invention of movable type, woodcuts started to be used to illustrate books.[51] In the

49 They were studied by Guerrini (2016) for the mystic Joachim of Fiore. She sees continuities with Raimundus Lullus, who often used diagrams (see chap. 12 §5 above). The rôle of diagrams in geometry and astronomy is studied in Acerbi (2020).

50 On such aids, see Korenjak (2016: 240).

51 Albrecht Pfister in Bamberg seems to have been the first to do so, around 1461.

course of a century, these illustrations reached unprecedented perfection, culminating in the work of artists like Albrecht Dürer (1471–1528). These illustrations may have played a similar rôle among the more descriptive sciences as mathematical formalisation had in the subsequent century for the more theoretical ones. Famous examples of works full of important and artistically outstanding illustrations are Fuchs's *Historia stirpium* (1542), Vesalius' *De humani corporis fabrica* (1543), Agricola's *De re metallica* (1556), or Gesner's *Historia animalium* (1551–1558). Such illustrations, based on minute observation, may be viewed as the central scientific advance in many of these books, thus also diminishing the importance of the language used in the text.[52] Some contemporary authors noticed this as well; according to Tommaso Campanella,[53] learning the sciences through images becomes much faster and easier. In his utopian state, the inhabitants depict the following sciences in images on their six temple walls: geometry and geography, mineralogy and botany, animals, and the inventors of the sciences, including prophets.

§9 Taken together, these factors had the result of replacing Latin as the sole carrier of Western European science. It was certainly political reasons (especially French nationalism) that weighed most heavily, while formalisation and illustrations eased the task of conveying scientific insights, which had become less dependent on natural language. It was of great importance to the success of the Scientific Revolution that the vocabulary was already available in Latin. As Crombie (1994: 1:12) puts it:

> They [early modern natural philosophers] came to express causality in the language not of subject and predicate but of algebraic functions, and they devised a new Latin terminology to express such fundamental quantities as velocity, acceleration, instantaneous velocity and so on. These quantities were defined in the 14th c. in Paris and Oxford and their terminology was used by Galileo and Newton.

Once this was available, science's transplantation into vernacular languages became much easier. But it is hard to imagine such an international phenomenon as the Scientific Revolution if Latin had lost its central positions a few centuries earlier.

Quite in general, it is usually power politics that decide what language is used in a cultural space: after the Arab conquests, Persian, Syriac, Indian, Spanish, and Jewish authors began to write Arabic, which thus became an important

52 See Rossi (1997: 60–67).

53 *Scientiarum faciles per picturam disciplinae* (*Civitas solis*, ed. Tornitore, p. 12).

international language, also for science. Today, authors from around the globe write in English if they wish to be read internationally. Nationalism in Europe had the disadvantageous consequence that one language of science was replaced with at least three that had to be learned by scientists. But this was an accident: the French in the eighteenth century obviously strove to replace Latin with French alone. Toward the end of the twentieth century, it seemed that the Germans (who lost the War) and even the French were being coerced into using English, which finished the struggle for hegemony as winner. With the likely demise of US world domination, other languages may take over from English as the main language of science, although this is not necessarily so: 'fixed' languages, such as Sumerian, Sanskrit, Greek, and Latin, were used for many centuries without a hegemonic power backing them. That science, with its own formal structures and the importance of illustrations, is today less dependent on language will ease the process of changing from English to its successor(s). Of course, a change of the language of science always produces heavy losses in general knowledge (only what is translated remains available, as we have seen in chap. 9 above). Machine translation may mitigate this problem in the future.[54] The next chapter will present a few examples of niches in which Latin survived longer, in some cases until today.

Excursus: Artificial languages

§10 The strong interventions in lexicon and syntax in the making of scientific scholastic Latin and then in the adaptation of the vernacular languages makes one wonder about their connection to artificially constructed languages. Besides technical languages that develop naturally, such as for instance the jargon of public administration (*Verwaltungssprache*) already in the Early Middle Ages,[55] quite a universal tendency for some individuals to 'improve' their language or to invent an altogether new one for a variety of reasons can be observed.[56] We have already met Lullus, who extended Latin by very free suffixation (chap. 12 §5). Among altogether newly created languages, a priori ones are distinguished from a posteriori ones. The latter 'improve' existing languages; the former are invented from scratch and presuppose an 'ontology' (a full classification of reality). Some

54 The German project DeepL (https://www.deepl.com) already (2020) produces surprisingly good translations of German science and philosophy into English.

55 See Norberg (1975: 89): its main characteristics were 'Klarheit und Objektivität' ('clarity and objectivity'). Its relation to scientific language would be interesting to study.

56 A systematic overview of such reasons can be found in in Bausani (1974). More narrowly on the early modern attempts, see Eco (1993).

of the former, such as George Dalgarno's *Ars signorum*,[57] could be very mathematical and logically structured, reminding us of Galileo's idea that mathematics is the language of God (see chap. 13 §4 above). The fact that this approach depended very heavily on the languages known to the author, the structure of which was inevitably based on what has been called Standard Average European,[58] and the ontology used depended on the European *Begriffsgemeinschaft* (see chap. 1 §10 above), makes these a priori languages look rather naïve today. The silent consensus today seems to be that no generally human ontology for the entirety of reality accessible to mankind exists.

The fact that the question of a universal language, or at least a universal language of erudition and science, becomes especially prominent in the second half of the seventeenth century is an indicator that the rôle of Latin for exactly this purpose had become less a matter of course. The first important attempts were partly still written in Latin, such as those by Dalgarno or Johann Joachim Becher,[59] and partly in vernaculars, especially English: John Wilkins[60] or Francis Lodwick.[61] Above (chap. 1 §4), it was seen that some authors, especially of the eighteenth and nineteenth centuries, saw 'purified', hyper-classical Latin as the perfect and universally usable language. These 'antibarbarus' authors must have known that they were fighting a losing battle. Their approach will be discussed further below (chap. 16 §1). Many of the later proposed artificial languages are still largely based on Latin (such as Esperanto, from 1887),[62] or are even conscious attempts to 'improve' Latin through simplifying language engineering, such as Giuseppe Peano's *Latino sine flectione* (from 1915). The idea that the morphology of a universal language should be as simple as possible is common to many such attempts, quite missing the point that vocabulary is usually the most time-consuming part of language acquisition. The natural development of languages with little or no morphology is to become highly idiomatic (as English or Chinese have),

57 In full *Ars signorum, vulgo character universalis et lingua philosophica* (Londini: Hayes, 1661). Its basic logic is explained by Bausani (1974: 105–106).

58 See Haspelmath (2001); the term comes from Whorf (1944: 200). Further examples of shared features in Job (2005). Many common features can be observed in Western European languages (articles, syntax, relative clauses, parts of the vocabulary's structure) that are shared not so much with Latin but among all peoples who were in contact with Charlemagne's empire: Romance, Germanic languages, to some extent also Slavonic ones, Finno-Ugric ones, Modern Greek. The term *Charlemagne Sprachbund* is sometimes used.

59 *Character pro notitia linguarum universali* (Francofurti: Joh. Wilh. Ammon, 1661).

60 *An Essay towards a Real Character, and a Philosophical Language* (London: Gellibrand, 1668).

61 *The Ground-Work, Or Foundation Laid, (or so intended) For the Framing of a New Perfect Language* (London: n.p., 1652).

62 See Libert (2004).

which hardly makes them easier to learn and use. Besides, Latin-based languages are of little help for people who do not already speak a Romance language. The topic of artificial languages seems to have rather cooled down in the twenty-first century, with the exception of programming languages, which have a much more restricted scope.

15 Niches where Latin survived longer

O quoties obitum linguae statuere Latinae!
Tot tamen exsequiis salva superstes erat.
'Oh how often have they declared the death of Latin! As many times it survived its funeral.'
Eberle (Sal niger, Sal 19)

§1 In fact, Latin did not cease to be of scientific importance in all branches of science and learning in the early nineteenth century. Its displacement happened later in parts of Europe where none of the three major languages was at home, as well as in some fields, such as philology and linguistics, where it was still alive and well in the middle of the nineteenth century or later (§1). Six niches where Latin continued to thrive into the twentieth century will be examined below (§§2–7).

We have seen that the vernaculars took over Latin's leading rôle as language of science and learning around the middle of the eighteenth century, but on the whole the development away from Latin was very slow and far from linear. There are still many important works first published in Latin throughout the eighteenth and the beginning of the nineteenth century, as the following sample shows.[1]

- Stochastics: Jacob Bernoulli, *Ars coniectandi* (Basileae, 1713).
- Botany: Samuel Gottlieb Gmelin, *Flora sibirica sive historia plantarum Sibiriae*, 4 vols (Petropolis, 1747–1769).
- Number *e* and analysis: Leonhard Euler, *Mechanica* (Petropolis, 1736) and *Introductio in analysin infinitorum* (Lausannae, 1748).
- Botany: Carl Linnaeus, *Systema naturae* (Lugduni Batavorum, 1735).
- Medicine: Albrecht von Haller, *Elementa physiologiae corporis humani*, 8 vols (Lausannae, 1757–1766).
- Physics: Rogerius Boscovicius, *Theoria philosophiae naturalis* (Venetiis, 1758).
- History of Iceland: Finnur Jónsson, *Historia ecclesiastica Islandiae* (Hafniae, 1772–1778).
- Homeric studies: Friedrich August Wolf, *Prolegomena ad Homerum* (Halis Saxonum, 1795).
- Algebra: Carl Friedrich Gauß, *Disquisitiones arithmeticae* (Leipzig, 1801).
- Magnetism: Hans Christian Ørsted, *Experimenta circa effectum conflictus electrici in acum magneticam* (Copenhagen, 1820).
- Comparative linguistics: Franz Bopp, *Glossarium sanscritum* (Berlin, 1830).

1 Ogilvie (2015: 266) similarly stresses the importance of Latin at the universities up to 1800.

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- Mycology: Elias Fries, *Systema mycologicum*, 4 vols (Greifswald, 1821–1832).
- Oriental studies: Georg Wilhelm Freytag, *Lexicon Arabico-Latinum*, 4 vols (Halle an der Saale, 1830–1837).
- Mycology: Giacomo Bresadola, *Iconographia mycologica*, 29 vols (Milan, 1929–1933).[2]

The list shows, that, geographically, the last bastion of scientific Latin was mostly among scholars in Germanic and eastern parts of Europe: Gmelin and Euler worked in the Russian Empire;[3] Boscovich stemmed from the Republic of Ragusa and was a Jesuit.[4] In Hungary there were even some Latin newspapers for a short time, for instance *Mercurius veridicus ex Hungaria* (Levoča, 1705–1710), *Nova posoniensia* (Bratislava, 1721–1722), or the *Ephemerides budenses* (Budapest, 1790–1793). As the list suggests, in these regions important publications first published in Latin continued all through the nineteenth century. For instance, the mycologist Fries continued to publish in Latin into old age (*Hymenomycetes europaei*, Uppsala, 1874). In Germany this trend is exemplified most famously by Carl Friedrich Gauß, who even kept his own private diary in Latin (Klein 1903). Even the later twentieth century saw some natural-scientific Latin publications, although they must certainly be seen as *curiosa*, for instance Fenske, *Extensio gradus,* a mathematical paper on Fredholm operators written in 1979. From the nineteenth century onward, scientific Latin is more and more confined to a shrinking number of niches, some of which are now considered.

(i) Titles and ornamental Latin

§2 Interestingly, books written in the vernacular often continued to use Latin titles from early on. Huser's edition (1603) of the works of Theophrastus Paracelsus (1493–1541)[5] is called *Opera*, and uses headings such as *Huserus benevolo lectori s[alutem]*, *Volumen medicinae Paramirum Theophrasti de medica industria*, *Libellus prologorum primus*, although the text is otherwise entirely written in German –

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2 See Kustatscher & Korenjak (2012: 1153–1154). The work is online at http://www2.muse.it/bresadola/iconographia.asp?pt=IV.

3 Both stemmed from German-speaking areas. But native Russian eighteenth-century scientists, such as Michael Lomonosov, besides writing in Russian (which was becoming an important language then) also wrote at least some publications in Latin.

4 He was introduced above (chap. 13 §4). More on the Jesuits as a last bastion of scientific Latin in §7 below.

5 Online at http://www.e-rara.ch/zut/content/titleinfo/3505565.

a German of a rather macaronic[6] character which uses Latin words and phrases all the time, but nonetheless German. It will be remembered (chap. 14 §2) that Paracelsus held his inauguration lecture in Basle in German, apparently to stress the novelty of his approach. Latin titles remained en vogue even after the time Latin ceased to be the usual medium of scientific communication. A few examples (the list could easily be extended):

- Ludwig Wittgenstein, *Tractatus logico-philosophicus* (London, 1921), in German and English.
- Johan Huizinga, *Homo ludens* (Haarlem, 1938), in Dutch (subtitle: *Proeve eener bepaling van het spel-element der cultuur*).
- Victor Klemperer, *LTI* [*Lingua Tertii Imperii*] (Berlin Ost, 1947), a book on Nazi language, in German (subtitle: *Notizbuch eines Philologen*).
- René Derolez, *Runica manuscripta* (Bruges, 1954), in English (subtitle: *The English Tradition*).
- Max Frisch, *Homo faber* (Berlin, 1957), a novel in German (subtitle: *Ein Bericht*).
- Walter Burkert, *Homo necans* (Berlin, 1972), in German (subtitle: *Interpretationen altgriechischer Opferriten und Mythen*).
- George Steiner, *Errata* (London, 1997), an autobiography in English (subtitle: *An Examined Life*).
- Thomas Leinkauf, *Mundus combinatus* (Berlin, 2009), in German (subtitle: *Studien zur Struktur der barocken Universalwissenschaft am Beispiel Athanasius Kirchers SJ*).
- Christian Jaser, *Ecclesia maledicens* (Tübingen, 2013), in German (subtitle: *Rituelle und zeremonielle Exkommunikationsformen im Mittelalter*).
- Johannes Fried, *Dies irae* (Munich, 2016), in German (subtitle: *Eine Geschichte des Weltuntergangs*).[7]

In general, such Latin titles seem especially common among authors who write in Germanic languages, among whom Latin, apparently, still enjoys high prestige. Nearly always, there is a subtitle in the book's actual language. The same applies to titles of book sections: in Schmitt's Anselm edition (1938) the first part is called *Ratio editionis*, despite being written entirely in German.

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6 The term derives from the *Opus macaronicum* (1517) by Theophilus Folengus (1491–1544), online at https://archive.org/details/opusmacaronicumn00foleuoft. For this kind of language and writing, see Berschin (1972).

7 The list does not include *Festschriften* in philological fields, which bear Latin names very frequently.

There would seem to be two reasons for doing this: on the one hand making use of Latin's prestige to make a work look cultivated, on the other hand the fact that certain titles, headings, and concepts are very familiar in Latin, especially in cases such as that of Schmitt.[8] Besides, it can be observed in the twenty-first century – a time in which only very few scientists, and even scholars in the human sciences, have more than a basic smattering of Latin – that something we could call ornamental Latin springs into life. Above (chap. 9 §6), we saw how Berschin aptly coined the term *ornamentales Griechisch* for the Middle Ages. What is happening today is similar: the motivations for using Latin are providing a semblance of erudition but also a wish to embellish one's writing with the odd Latin term. Of course, the Latin is not always used in a way that makes sense in Latin (as was the case with Greek in the Latin Middle Ages). On the Internet and even in book publications, such pseudo-Latin abounds in certain circles these days. A recent example is David H. Cropley's *Homo Problematis Solvendis – Problem-Solving Man: A History of Human Creativity*, published by no less than the renowned Springer publishing house in 2019. The author teaches at the University of South Australia. His syntactically nonsensical Latin reminds one of Monty Python's famous *Romanes eunt domus* ('People called Romanes, they go the house'), in this case something like 'a man for those to solve of a problem'. Due to lack of knowledge of Latin among writers and readers alike, it matters little whether such 'Latin' is really Latin or not.

In fact, an ancient language that is no longer actively used among the *intelligentia* becomes rather unsuitable for expressing very modern thoughts that a Roman or a mediaeval scholastic would only have grasped after lengthy explanation. Thus, what authors such as Voltaire (chap. 14 §5 above) claimed, has become a self-fulfilling prophecy: the less the *intelligentia* cultivate Latin, the less Latin can keep pace with recent intellectual developments.

(ii) Crypto-Latin

§3 Another niche for Latin was the concealment of indecent content. We propose the term 'crypto-Latin', from κρύπτω ('keep covered, esp. for purposes of concealment'), for this function.[9] Authors using crypto-Latin obviously believed Latinate

8 Schmitt was able to write scholarly Latin. In Anselm's *Opera*, p. *1, it becomes clear that the introductory part was planned to be written in Latin in 1938 but the publisher then decided that the edition did not need an introduction. In the second printing, in 1962, in different times, Schmitt finally wrote it in German.

9 Strictly speaking, this term would rather imply that Latin was hidden (consider a crypto-Catholic, who hides his confession), but the prefix 'crypto-' does also have a similar use in some cases, such as 'cryptography', where writing is not hidden but is used to hide the content.

people were mentally stable enough not to be put at risk by reading about indecencies, whereas simple – not Latinate – people might be tempted to imitate these indecencies or perversions. But there were also other, though related, reasons to hide behind Latin, such as in the early example of Nicolas Edme Restif de la Bretonne's autobiography *Monsieur Nicolas, ou Le cœur humain dévoilé*, published in 16 fascicles between 1794 and 1797. The most censure-worthy erotic details in this French book are written in Latin, for instance:

> Je devins concentré, taciturne, sauvage, furieux de luxure; mais l'unique objet de ma frénésie était Colette, *adhuc virgo a nullo tacta viro*. (Restif de la Bretonne 1883: 4:27)
> Les vêpres des Cordeliers ne duraient que trois quarts d'heure. Il fallait prévenir le retour du monde, et cependant Madelon *bis terna venere fuit locupletata*, dans ce court intervalle! ... Je ne pouvais la quitter. (4:145–146)
> 'I became concentrated, taciturn, wild, furious with lust; but the only object of my frenzy was Colette, *adhuc virgo a nullo tacta viro*.[10]
> Vespers at Les Cordeliers lasted only three-quarters of an hour. It was necessary to expect the return of the people, and yet *Madelon bis terna venere fuit locupletata*, in this short interval! ... I could not leave off of her.'

He often also quotes longer excerpts from his journal in Latin, also mostly containing sexual adventures (e.g. 4:224). This author is quite unusual in telling his readers why he uses Latin:

> Pour exprimer ceci, j'emploierai une langue savante, que les hommes seront forcés de traduire décemment aux femmes. (1:52)
> 'To express this, I will use a learned language, which men will be forced to translate decently to women.'

Women should not be able to read the more intimate sexual details. A more typical later, academic example of crypto-Latin is Krafft-Ebing's *Psychopathia sexualis*, published in 1886.[11] Although the book was written in German, reports about some of his patients' behaviour that were seen as especially pathological are written in Latin; the author switches languages in the midst of a description without any comment. An example (von Krafft-Ebing 1886: 245):

> Pat. war schwächlich als Kind, nervös, litt an nächtlichem Aufschrecken gleich seinem Vater, war aber von schweren Krankheiten nie heimgesucht bis auf Coxitis, seit welcher Pat. etwas hinkt. Sehr früh erwachten sexuale Dränge. Mit 8 Jahren, ohne alle Verführung, begann er zu masturbiren. Vom 14. Jahre ab ejaculirte er Sperma. Geistig war er gut veranlagt, inter-

10 In keeping with the authors' apparent wish, I refrain from translating these Latin passages.
11 Interestingly, a Russian scholar, Heinrich Kaan, had written a similar work with the same Latin title in 1844, but then still fully in Latin.

> essirte sich auch für Kunst und Literatur. Er war von jeher muskelschwach und hatte nie Neigung zu Knabenspielen und auch später nicht zu männlicher Beschäftigung. Er hatte ein gewisses Interesse für weibliche Toiletten, Putz und weibliche Beschäftigung. Schon von der Pubertät an bemerkte Pat. eine ihm unerklärliche Neigung für männliche Personen. Besonders sympathisch waren ihm junge Burschen aus den untersten Volksklassen. Ganz besonders zogen ihn Cavalleristen an. Impetu libidinoso saepe affectus est ad tales homines aversos se premere. Quodsi in turba populi, si occasio fuerit bene successit, voluptate erat perfusus; ab vigesimo secundo anno interdum talis occasionibus semen eiaculavit. Ab hoc tempore idem factum est si quis, qui ipsi placuit, manum ad femora posuerat. Ab hinc metuit ne viris manum adferret. Maxime periculosos sibi homines plebeios fuscis et adstrictis bracis indutos esse putat. Summum gaudium ei esset si viros tales amplecti et ad se trahere sibi concessum esset; sed patriae mores hoc fieri vetant. Paederastia ei displacet: magnam voluptatem genitalium virorum adspectus ei affert. Virorum occurrentium genitalia adspici semper coactus est. Im Theater, Circus u. s. w. interessiren ihn nur männliche Darsteller. Eine Neigung zu Damen will Pat. nie bemerkt haben. Er geht ihnen nicht aus dem Wege, tanzt sogar gelegentlich mit ihnen, aber er verspürt dabei nie die geringste sinnliche Regung.
>
> 'Patient was weak as a child, nervous, suffered from night terrors like his father had, but he was never afflicted by serious illnesses except for coxitis, since which patient has been limping a little. Very early sexual urges awakened. At the age of eight, without any seduction, he started to masturbate. From the age of fourteen he ejaculated sperm. Mentally he was well disposed, he was also interested in art and literature. He had always been weak-muscled and never had a tendency to play boys' games, or to engage in manly occupations later. He had a certain interest in female clothing, make-up, and female occupations. Already from puberty on, Patient noticed an inclination toward male persons which was inexplicable to himself. He was particularly fond of young boys from the lowest social classes. Most particularly, he was attracted to cavalrymen. *Impetu libidinoso saepe affectus est ad tales homines aversos se premere. Quodsi in turba populi, si occasio fuerit bene successit, voluptate erat perfusus; ab vigesimo secundo anno interdum talis occasionibus semen eiaculavit. Ab hoc tempore idem factum est si quis, qui ipsi placuit, manum ad femora posuerat. Ab hinc metuit ne viris manum adferret. Maxime periculosos sibi homines plebeios fuscis et adstrictis bracis indutos esse putat. Summum gaudium ei esset si viros tales amplecti et ad se trahere sibi concessum esset; sed patriae mores hoc fieri vetant. Paederastia ei displacet: magnam voluptatem genitalium virorum adspectus ei affert. Virorum occurrentium genitalia adspici semper coactus est.* In the theatre, circus, etc., only male performers interest him. Patient claims to have never noticed an inclination toward ladies. He does not avoid them, even dances with them occasionally, but he never feels the slightest sensual impulse.'

For the same reasons, sometimes in translations of 'explicit' Greek texts, passages were translated into Latin within a translation into a vernacular. Some such examples have been collected by Stray:[12] for instance, the 1917 Loeb edition of the Alexandrian novel-writer Achilles Tatius, *De Clitophontis et Leucippes amori-*

12 Lawton (2012: 189). The Achilles Tatius passage is II.37–38, ed. Gaselee, pp. 129–133.

bus, translates the final one and a half chapters of book II, which compare the experience of sex with boys and with women, into Latin although the text is otherwise translated into English. The translator does not comment on his change of language in the middle of a chapter, but the idea behind it is clearly the one proposed at the beginning of this section: uneducated people might be tempted to try out such things. It would be interesting to study this phenomenon in more depth. It can be seen as a special kind of *Fachwerkstil* (described in chap. 16 §4 below).

Interestingly enough, some crypto-Latin is still in use today, although not so much for indecent matters, which now no longer tend to be seen as problematic. For instance, in Switzerland pharmaceutical companies are not legally compelled to provide a full list of the ingredients of their medication, so they often list the major substances in the pill and add: *excipiens pro compresso* (sometimes adding *obducto*). The phrase literally means 'excepting [substances] for the completed pill' and is used as a means of concealing further, 'minor' substances in it, for various reasons. Thus, here Latin is also used to conceal information.[13] The ingredients that are mentioned are still also listed in a 'Latin' form, such as *Minocyclinum ut Minocyclini hydrochloridum*. But there is no reason to see crypto-Latin here, as the names of the chemicals are the usual international ones with an *-um* at the end. The reader of such pharmaceutical 'literature' only needs to know that Latin genitives of neuter nouns in *-um* end in *-i* and that *ut* means 'as, in the form of'. This seems more to be a survival of pharmacists' Latin. The following niches for Latin were more substantial.

(iii) University dissertations

§4 Doctoral dissertations were an important niche. At least in the human sciences, it was not unusual for dissertations to be written in Latin even in the middle of the twentieth century.[14] In the nineteenth century, it was rather unusual to write any dissertation in any other language in Europe. As an example, the University of Greifswald allowed German as well as Latin for medical dissertations only in 1867, for juristic ones in 1876, and for all fields in the *Geisteswissenschaften* in 1879.[15] University teaching had already been done in the vernacular languages in many places for about a century by then. Greifswald is an interesting

13 A brief Internet search brings up blogs where (e.g. allergic) people discuss what these ominous words might mean, and then vent their (justified) anger about not being informed properly.
14 Marti (1998). For an overview of theses and dissertations in early modern times in general, see Marti (2001).
15 The numbers and the information that follows are from Alvermann (2018).

case, as one can see here that there was not necessarily a linear development from Latin to the vernacular at universities. Already in 1739, Augustin von Balthasar wrote a German dissertation and in 1753 Hermann Ahlwardt tried to prove the fitness of German in *Den vorzüglichen nutzen der Teutschen Sprache angestellten Akademischen Streithandlungen* ('The Formidable Usefulness of Academic Disputations Held in German').[16] But as Greifswald then became part of the Swedish Empire, the use of Latin rose again in the late eighteenth century (as in Sweden generally). In 1794 the 'Greifswald consensus' reached the compromise that pure sciences had to use Latin, whereas applied sciences (*artes*) could use German or Latin, thus upholding a distinction that had come about centuries earlier. In comparison, the Habsburg lands already allowed German as a teaching language in 1784. Universities used Latin as the common spoken language at least until the middle of the eighteenth century almost everywhere.[17]

Cicero and Quintilian were often used as models for the language employed in dissertations, as their Latin was the kind drilled at the *gymnasium*. But academic Latin was certainly much more indebted to mediaeval and scholastic Latin than many of its more classicist users would have liked to admit.[18] Swedish Latin dissertations are currently being studied in detail.[19] Benner & Tengström (1977) studied the language of ten Swedish learned texts (mostly dissertations) from the seventeenth century. Initial conclusions about the literary background, vocabulary (esp. 52–61), grammar, and style were reached. But it was still too early to move far beyond rather general results such as the following (106):

> The learned Neo-Latin of the 17th century cannot be said to have been a 'dead' or petrified language, not even a dying one. It was subjected to certain changes, mostly concerning the vocabulary. It could be moulded to very different purposes and be adapted to various styles.

In the meantime, significant advances have been made. For instance, Sjökvist (2012: 38–57) provides a list of rare terms and neologisms in three Swedish musicology dissertations from the seventeenth century. He finds that most neologisms (94 of 111) are nouns, something that does not seem to be typical, as the data below in appendix 1 (context: chap. 18 §4) shows. Among the often-quoted advantages of Latin are its elaboration and adaptation to many fields, its already existing specialised vocabulary, the general *usus*, and possibly sometimes also the fact that some technical knowledge should not reach simple people (see §2 above on crypto-Latin).

16 Online at http://mdz-nbn-resolving.de/urn:nbn:de:bvb:12-bsb10667132-4.
17 Dates when this changed for several European universities in Waquet (1998: 38–42).
18 Hörstedt (2018: 39) comes to the same conclusion.
19 e.g. Helander (2004); Gunnarsson (2011); Sjökvist (2012); Hörstedt (2018).

(iv) Botany

§5 Botany, like medicine, already had a highly specialised, vast vocabulary in the days of Carl Linnaeus (1707–1778), the father of modern botany, who still wrote in Latin. He invented the modern binomial biological nomenclature for species, formed of the Latin or Latinised genus name followed by a species name (such as *Homo sapiens*). Even today, most plant genera bear names that are one of the following.[20]

- (Latinised) Greek or Latin names from Antiquity (such as the genera *Acacia*, *Aconitum*; *Allium*, *Apium*, *Brassica*).
- Mediaeval Latin ones (*Humulus*, *Maiorana*, *Primula*).
- Oriental, often Arabic, ones, mostly for non-European plants (*Camphora, Catha*).
- More rarely, from the mediaeval European vernacular languages (*Canella, Galega*).
- Modern coinings from Greek and Latin elements (*Aceriphyllum, Alternanthera*).
- Modern coinings based on botanists' names (*Maclura*, *Rudolfiella*).
- *Wucherformen* such as *Echinofossulocactus, Gymnanthocereus.*[21]

Species names are usually originally adjectives characterising the species within the genus (often: *vulgaris, sativus, medicinalis*) or genitives (*Magnolia sieboldii*), but sometimes the two names are rather to be understood as a kind of apposition: *Pistacia lentiscus* = a *pistacia* that is called *lentiscus*. This system is maintained to this day, so discoverers of new species must at least be able to put the adjective into the correct gender or genitive form in Latin. Very rarely do we find names that would seem badly formed, like *Solanum dulcamara*, in which *dulcamarus* (a rare and late compound used e.g. once by Iustus Lipsius as *dulcamaro sermone*)[22] should be neuter. Some name forms look erroneous but are not, thus *Schinus molle*, a tree from Peru which produces pepper-like fruit, where one would expect that *schinus*, being a feminine (from σχῖνος, 'mastic-tree'), should take *mollis;* but *molle* is a non-Latin noun used as an apposition here.[23] Some botanical sources do indeed 'correct' to *mollis*. The same genus once contained an erroneous name: Antonio José Cavanilles (1745–1804) named a tree *Amyris polygamus*, which was

20 The list follows Genaust (1976: 12–18).

21 Groups from Genaust (1976). He was not able to trace the etymologies for some thirty genera.

22 In *Sylloge epistolarum a viris illustribus scriptarum,* vol. 1, ep. 264, found using Corpus Corporum. The word is documented in the Hungarian Mediaeval Latin dictionary by Harmatta et al.

23 Linnaeus, *Species plantarum,* pp. 388–389, took the name from Monardes, *De simplicibus medicamentis,* p. 48, who describes the tree and quotes its native American name as 'Molle'.

placed into our genus in 1937 as (wrongly) *Schinus polygamus*, later corrected to *Schinus polygama*, as *schinus* is a feminine noun.[24]

This complicated and highly functional Latin-based system of nomenclature made a transition to the vernacular languages especially problematic.[25] Indeed, these Latin names are still the only ones used in scientific contexts. Moreover, new plant species had to be described by their discoverer in a highly standardised Latin that owed much of its characteristics to Linnaeus, until 2014. Special manuals taught this kind of international language, such as Stearn (1966). Since 2015 these first descriptions may also be written in English (which, of course, means that they are now exclusively written in English). As an example, we can quote the Latin description of *Wollemia nobilis*, a famous living fossil discovered in Australia in 1994. Not only the species was new to science but also the genus. A short Latin description of the new genus is given, before further description in English:[26]

> *Agathi affinis, sed characteribus sequentibus differt: folia trimorpha, helicalis, decurrentia; strobili terminales, bracteae squamaeque perfecte connatae spiniferaeque; semina ala cincta.*
> 'Similar to the genus *Agathis*, but it differs from it in the following respects: trimorphic, winding, hanging leaves; terminal cones; perfectly connate and spine-bearing lamellae and scales; the seeds are girded by a wing.'

The same procedure is repeated for the species:

> *Arbor elata cortice nodosa spongiosaque; rami inferi foliis distichis, linearibus, obtusis, hyperstomaticis; rami superiori foliis tetrastichis, oblongis, obtusis, amphistomaticis; strobuli masculi magni, 7–11 cm longi, 13–19 mm diametro.*
> 'High tree with knotty and porous bark; the lower branches with two-rowed, linear, obtuse, hyperstomatic leaves, the upper ones with four-rowed, oblong, obtuse, amphistomatic leaves; the male cones are big, 7–11 cm long with a diameter of 13–19 mm.'

At the end, the sentence 'We thank [...] Peter Wilson for assistance with Latin diagnoses' reveals that a few Latin specialists occupied themselves with polishing or even translating these Latin 'diagnoses' up to 2015. Of course, even now, without hardly any more Latin diagnoses published, Latin still has its place in botany: the names of new species are still chosen following the Latin rules detailed above. As the list above shows, entire Latin monographs were still frequent all through the nineteenth century in this discipline.

24 http://www.ipni.org/ipni/idPlantNameSearch.do?id=1073576-2 .
25 Also pointed out by Korenjak (2016: 160).
26 From Jones, Hill & Allen (1995).

(v) Philology, especially classical philology

§6 A field in which Latin had an obvious advantage was classical philology. Those studying it cannot avoid knowing Latin. Through the nineteenth century, Latin was used as a matter of course in many publications in this field. In 1892, Wilamowitz-Moellendorff predicted that the twentieth century would bring 'die Abschaffung des Griechischen und Beschränkung des Lateinischen auf einen elementaren Sprachunterricht' ('the abolition of Greek and the restriction of Latin to elementary language teaching') in school.[27] He continued to claim that despite the fact that the German people 'den Bruch mit der Geschichte und der Kultur endgültig vollzöge' ('would break with its history and culture for good'), classical philologists would continue to exist at universities, albeit more like semitologists or indologists, as specialists of faraway languages and cultures. Wilamowitz-Moellendorff was right. Thus, although Latin had stayed alive as an important written language far into the nineteenth century in classical philology, it diminished even in this rôle in the twentieth. Some of the most important contributions to the field were still written in Latin, for instance Karl Lachmann's *In T. Lucretii Cari De rerum natura libros commentarius* (Berlin, 1850). Heiberg in his Euclid edition from 1883 still translates the Greek texts into Latin, not one of the vernacular languages, since he believes (vol. 1, p. viii):

> *Nam quamquam videbam, Latinam interpretationem meam a nonnullis improbari, tamen hic quoque Latinam Francogallicae Germanaeve aut nulli praetuli; nam interpretationem mathematici flagitant, et Latina a pluribus legi potest.*
> 'For although I foresaw that some would disapprove of my Latin translation, I yet prefer one in Latin to one in French, German, or none at all, for mathematicians demand a translation and Latin is read by most.'

For the very same reasons, many important grammars and dictionaries of oriental languages were still written in Latin in the nineteenth century, such as Carolus Paulus Caspari's *Grammatica arabica in usum scholarum academicarum* (Leipzig, 1848),[28] or Georg Wilhelm Freytag's *Lexicon arabico-latinum* (Halle an der Saale, 1830–1837), which is still today often indispensable and sometimes superior to Lane's large standard Arabic–English dictionary. Even in 1920, Tkatsch still translated the Arabic version of Aristotle's *Poetics* from Arabic into Latin as a kind of 'neutral' language in which he hoped to be able to imitate the syntactic and lexi-

27 In a speech printed in Wilamowitz-Moellendorff (1901: 101). Quoted and discussed in Fuhrmann (2001: 217).

28 Online at http://reader.digitale-sammlungen.de/en/fs1/object/display/bsb10571520_00053.html.

cal details of the Arabic in order to acquaint the non-Arabist scholar with them.[29] Other orientalists strongly disagreed; the great Syriac scholar Baumstark called Latin a 'fragwürdiger Aufputz pseudociceronianischer Sprache' ('questionable finery of pseudo-Ciceronian language') in 1900. These emotional words clearly show that Latin was still one of several possible languages for orientalist scholarship, but Baumstark continues 'dass kaum irgendeine Sprache zur Übersetzung semitischer Texte und zur Behandlung semitistischer Gegenstände minder geeignet ist als die lateinische' ('that hardly any other language is less suitable for the translation of Semitic texts and the treatment of Semitic subjects than Latin'; 1900: x).

Semitists, indeed, stopped using Latin in the first half of the twentieth century. In contrast, Latin has been retained especially tenaciously as the language of prefaces to monolingual editions of texts in the classical languages. The matters to be discussed are rather monotonous, and it will be felt that readers who can read the Latin or Greek edited text will not be put off by a Latin introduction, and will certainly understand it, in contrast to any single one of the vernaculars. In the Bibliotheca scriptorum graecorum et romanorum teubneriana, and until recently in the Oxford Classical Texts, prefaces were universally written in Latin. The first exception for the latter series was the English preface by Lloyd-Jones and Wilson in their Sophocles edition (1990). Occasionally, even in the twenty-first century scholarly research papers are written in Latin, for instance Briesemeister & Schönberger, *De litteris neolatinis* (published in 2002). But as schools do not teach Latin composition any more, those able to write Latin are becoming fewer and fewer.

(vi) Catholic theology, especially Jesuit school Latin

§7 Latin was largely used as the medium of communication within the Catholic Church before Vatican II (1962–1965), which famously abolished Latin Mass and in general strove to modernise the Church. Theological works were still often written in Latin in the twentieth century, as the list below will illustrate. The Roman Pontificia Università Gregoriana, a university originating from the Jesuit Collegium Romanum, taught theology in Latin until the late 1960s. Today the Vatican still offers parts of its homepage in Latin,[30] mostly a collection of legal texts, encyclicals, letters, and so on. In contrast, the main page containing practical and pas-

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29 Petitmengin (2012) ventured a foray into the uncharted waters of French translators who translated from Greek to Latin in the nineteenth century.

30 http://www.vatican.va/latin/latin_index.html .

toral matters exists in several modern languages but not in Latin (as of 2018). From 1566 to 1989, the Church used the *Catechismus romanus*, from 1990 on the *Catechismus catholicae ecclesiae;* for both, the Latin version remains the authoritative one. Although not affiliated with the Church, Rome is today again home to a college where Latin (and Ancient Greek) are exclusively used in teaching: the Vivarium Novum.[31] In 2007, Pope Benedict XVI opened a back door for the abolished Latin Mass with his encyclical *Summorum pontificum*.[32] Since then, Latin Mass can quite regularly be heard again in some churches. Thus, Latin can still be said to be alive to some extent in the Catholic environment.

Since its formation in 1540 by Ignatius of Loyola, the Jesuit Order was especially dedicated to teaching and science.[33] Of course, back then teaching meant teaching in Latin. For political reasons, the order was suppressed in 1773–1814 (except in Prussia and the Russian Empire, which did not want to lose their Jesuit schools); afterwards, it had much less influence over a very different world, but it clung tenaciously to Latin. School textbooks used in Jesuit schools remained in Latin throughout the first half of the twentieth century. Strictly speaking, this may be more school Latin than scientific Latin, but the structure would be the same in scientific use. It may be useful to quote a paragraph of this largely forgotten kind of twentieth-century Latin. Carolus Boyer explains biological evolution in 1952 (*Cursus philosophiae* q. 4, a. 2, §1.IIA, vol. 2, p. 185):

> *Transformismus universalis est simul vel monisticus vel theisticus; monisticus quidem, si evolutionem aut casu et fortuna, aut vi quadam immanente integre explicat. Ita Darwin, qui transformismum specierum explicat praesertim per selectionem naturalem: scilicet, ex multis formis parum diversis quae generatione oriuntur, illae tantum permanent quae aptiores sunt ad pugnam pro vita ('struggle for life'); debiliores autem pereunt; magnum influxum quoque exercet selectio sexualis, quae resultat ex pugnis inter mares et ex inclinationibus feminarum. Sic continuis et parvis mutationibus paulatim magnae differentiae acquiruntur, dum formae intermediae pereunt. Cui systemati Weissmann addidit selectionem intragerminalem, quae nempe fiat inter determinantia, seu elementa chromosomatum, in cellulis generationis.*
> 'Universal transformism (evolution theory) is at the same time either monistic or theistic. Monistic if it explains evolution fully either by accident or chance, or by another immanent force. This is done by Darwin, who explains the transformations of species particularly by natural selection, i.e. out of many slightly different forms that are generated, only those remain that are better adapted to the struggle for life. The weaker ones die. Another great influence is exercised by sexual selection resulting from fighting between males and from the

31 In Frascati on the outskirts of Rome, https://vivariumnovum.net; the name alludes to Cassiodorus' Vivarium.

32 Online at http://w2.vatican.va/content/benedict-xvi/la/motu_proprio/documents/hf_ben-xvi_motu-proprio_20070707_summorum-pontificum.html.

33 See Feingold (2003a).

> predilections of females. Thus, large differences are by and by acquired through continuous and small changes, whereas the middle forms disappear. To this system [August] Weismann added intra-germinal selection, which happens among genes or chromosomes in germ cells.'

Later on, more theistic alternatives are also discussed. This is a language that is easily understandable but expresses its modern scientific content effortlessly. It could very well have been used as an international scientific auxiliary. It can be called pragmatic Latin.[34] For a variety of reasons – politics, school curricula de-emphasising Latin, dislike outside the Catholic Church of all things Jesuit, last and not least Vatican II – this did not happen, and this kind of Latin has been so utterly forgotten in the past half-century that it looks like a lost continent to us today. In order to give an impression of its size and importance, a chronological list of some such twentieth-century Jesuit textbooks dealing with scientific topics (*sensu lato*) is presented here; many of them were intended for school use but some also for higher, university studies.[35]

- Stanislaus De Backer, *Institutiones metaphysicae specialis*, 4 vols (Paris: Delhomme et Briguet (vols 1–2); Beauchesne (vols 3–4), 1899–1904). Vol. 1, *Cosmologia, cui adnexa est disputatio de accidente*. Vol. 2, *De vita organica*. Vol. 3, *De vita rationali*. Vol. 4, *Theologia naturalis*.
- René Jeannière, *Criteriologia vel critica cognitionis certae* (Paris: Beauchesne, 1912).
- Aurelius Palmieri, *Theologia dogmatica orthodoxa (ecclesiae Graeco-Russicae) ad lumen Catholicae doctrinae examinata et discussa* (Florence: Libr. Editr. Fiorentina, 1911–1913).
- Victor Cathrein, *Philosophia moralis*, 10th ed. (Freiburg im Breisgau: Herder, 1915).
- Joseph Donat, *Ethica*, 2 vols (Innsbruck: Rauch, 1921).
- Friedrich August Klimke, *Institutiones historiae philosophiae*, 2 vols (Rome: Univ. Gregoriana, 1923).
- A. R. P. Eduardus Hugon, *Cursus philosophiae thomisticae: Philosophiae naturalis*, vol. 2, *Cosmologia, biologia, psychologia* (Paris: sumptibus P. Lethielleux, 1927).
- Martin Jugie, *Theologia dogmatica christianorum orientalium ab ecclesia catholica dissidentium*, 5 vols (Paris: Letouzey et Ané, 1926–1935).

34 As does Leonhardt (2013: 243), contrasting it with humanist Latin.
35 I mention the editions I happened to have access to. Many of these books are hard to find even in large university libraries today. Protestant Zurich (where I am writing) is especially badly stocked with this kind of literature.

- Joseph Fröbes, *Psychologia speculativa* (Freiburg im Breisgau: Herder, 1927). Also as a *cursus brevior* (1933).
- Louis de Raeymaeker, *Introductio generalis ad philosophiam Thomisticam*, 2 vols (Leuven: Nova et vetera, 1931).
- Louis de Raeymaeker, *Metaphysica generalis*, 2 vols (Leuven: apud E. Warny, 1935).
- Carolus Boyer, *Cursus philosophiae*, 2 vols (Paris: Desclée de Brouwer, 1952).
- *Philosophiae scholasticae summa*, 3 vols (Madrid: Biblioteca de Autores Cristianos, 1952–1957). Vol. 1, *Introductio in philosophiam, Logica, Critica, Metaphysica generalis*, by Leovigildo Salcedo & Jesús Iturrioz. Vol. 2, *Cosmologia, Psychologia speculativa*, by José Hellín & Ferdinando M. Palmes. Vol. 3, *Theodicea, Ethica*, by José Hellín & Ireneo González.
- Paul Siwek, *Psychologia metaphysica: Institutiones philosophiae aristotelico-scholasticae*, 5th ed. (Rome: Pont. Univ. Gregoriana, 1956).
- *Institutiones philosophiae scholasticae*, 6 vols (Freiburg im Breisgau: Herder, 1925–1964). Vol. 1, *Logica cui praemittitur introductio in philosophiam*, ed. J. de Vries. Vol. 2, *Critica*, ed. J. de Vries. Vol. 3, *Ontologia*, ed. J. B. Lots. Vol. 4, *Philosophia naturalis in usum scholarum*, ed. Carl Frank. Vol. 5, *Psychologia metaphysica*, ed. Alexander Willwoll. Vol. 6, *Theologia naturalis*, ed. Walter Brugger.

This list could easily be extended, but it will be sufficient to show the vitality of the genre up to Vatican II, which brought this lively tradition to an abrupt end, together with many other pieces of centuries-old culture.[36] Among the authors, we find Poles, Spaniards, Italians, Frenchmen, Austrians, and Germans:[37] there was a truly international auxiliary language for the sciences and education.

The structure of the argumentation in most of these books was very similar to the traditional scholastic approach: there are *quaestiones, articuli, scholia, respondeo, argumenta*. The authors do not mind using neologisms in their vocabulary, often shaped according to vernacular usage if the words are correctly formed from Latin and Greek constituents:[38] *palaeontologia*, *fossile*, *anthropomorphicus*, *evolutionismus*, *transformismus*, *creationismus vel fixismus*,[39] *monophyleticus*, *idealista*,

36 Internet searches reveal that even today, there is still a strong opposition to the new post-Vatican II Catholicism in some circles.
37 The English are missing because Catholicism was outlawed until the nineteenth century and the Catholic structures had by then all but disappeared.
38 Examples from Boyer, *Cursus philosophiae*; the text is searchable online at http://mlat.uzh.ch/?c=4&w=BoyCar.CurPhil.
39 Which is, incidentally and in contrast to many Protestant sects still today, rightly rejected as unscientific by Boyer, *Cursus philosophiae*, *Psychologia* q. 4, a. 2, §1.IIC, vol. 2, pp. 186–187.

elementa chromosomatum, *conatus vitalis* (*élan vital*), *determinantia* (i.e. genes), *scientista*, *positivista*, *liceitas* – words that would be seen as the pinnacle of barbarism by Ciceronians, for whom this kind of Latin would be at least halfway toward Giuseppe Peano's *Latino sine flexione* (chap. 14 §10). But such criticism seems ill-founded and based on a misunderstanding of the nature and function of language: Latin as a living language of erudition would have to behave exactly as it does in these Jesuit manuals if it was to function well. That it was discontinued was purely a political decision. The next chapter presents selected aspects of the change from Latin to vernacular in science and learning.

16 From Latin to vernacular science

> If you think that one language for science improves efficiency and understanding, the rejection of Latin appears as a monument to human folly.
>
> Gordin (2015b: 24)

§1 This concluding chapter of part 2 of this book considers how Latin's rôle as the leading language of science and learning came to an end. Above (chap. 14), we have seen that the eighteenth century was crucial to ending Latin's hegemony in science. First, the more general question is taken up of whether Latin is now finally dead (§1); Latin's main advantage, its stability in time, is considered (§2); then the question of how the vernaculars had to adapt to become vehicles of science is briefly tackled (§§3–5); and finally, the general situation is evaluated (§6). The further development of vernacular science is outside the scope of this book; the linguistic changes to Latin will be the topic of part 3.

Now, if even in scientific communication and in the Catholic Church, which may have been the two last bastions of Latin, Latin is practically no longer used today, we may wonder: is Latin now a truly dead language? It is definitely extinct as a language with native speakers who learn it from their parents. That ceased to be the case a long time ago. But does this mean that it is dead? Those native speakers developed their way of speaking, which produced the Romance languages. But rhetorical Classical Latin was not the language of everyday life, as even a cursory comparison between Cicero's orations and his familiar letters shows.[1] Thus, from very early on, literary Latin began to be disconnected from the spoken language. This situation can be seen as continuing until the nineteenth century, when Latin lost the most important position among school subjects.

Among humanists from Lorenzo Valla[2] to our own days, who only consider literature written by native speakers as of intrinsic value, this situation is completely misjudged. An entire genre of 'antibarbarus' literature meaning to purge Latin grew up over the centuries, culminating in Krebs's *Antibarbarus,* which was last reworked by Joseph Hermann Schmalz and printed in Basle in 1905. For Krebs, Latin from Late Antiquity is already of questionable value because the spoken language had drifted away from the written one. The simple amount of scientific, philosophical, and other relevant Latin texts, which is much greater and was

1 See chap. 8 §7 above. Leonhardt (2013: 78) points out that '[a]fter Cicero, however, the vernacular disappeared from literature'.

2 In his *Elegantiae linguae latinae* of 1471. In contrast to later authors, Valla saw himself as a native speaker of Latin, albeit in a colloquial form ('Italian'), in a way similar to modern Arabs, as is pointed out below.

https://doi.org/10.1515/9783110745832-017

much more influential than in the case of purist Latin, provides a first hint that the Ciceronians' argument misses the point. In contrast, such extreme 'humanism' was sometimes accused of having killed the 'living' Mediaeval Latin with a straight-jacket of Ciceronianism, for instance by Norden (1958: 2:767):

> Der lateinischen Sprache, die im Mittelalter nie ganz aufgehört hatte zu leben und demgemäß Veränderungen aller Art unterworfen gewesen war, wurde von denselben Männern, die sich einbildeten, sie zu neuem dauerndem Leben zu erwecken, sie zu einer internationalen Kultursprache zu machen, der Todesstoß gegeben.
> 'The Latin language, which had never completely ceased to live in the Middle Ages and had therefore been subject to changes of all kinds, was dealt its death blow by the same men who imagined that they could awaken it to new permanent life, make it an international cultural language.'

Taking into account the argument in this book, it is clear that this is at least exaggerated: in fact, 'normal', non-humanist Latin continued to flourish in early modern times,[3] but the humanist criticism and its later consequence of disregarding 'non-native' Latin literature is nevertheless clearly obsolete today, as we understand much more about written and oral forms of languages. In fact, there are many similar cases of diverging written and spoken language: Swiss Germans write Standard German but speak dialects that can be as far from it as Italian is from Latin. The school language is different from one's mother tongue, and people learn to express complicated (e.g. scientific) thought only in the former. The parallelism goes even further: depending on the amount of nationalism, people will still try to formulate 'higher' things in their dialect (as the Swiss Germans do),[4] or they switch to the standard language when speaking about such matters (as Italians or Bavarians would). For the less cultivated, it feels awkward to speak the written language and they may commit errors induced by their spoken variety, both in spoken and in written Standard German. And yet, who would claim that Swiss authors such as Gottfried Keller or Friedrich Dürrenmatt wrote a language that was dead for them, were not native speakers of German, and that their works are therefore of no value? This phenomenon was first studied in depth by Charles A. Ferguson (1959), who spoke of 'diglossia'. The difference is, of course, that there is Germany, where the 'dead' language can be experienced in action for the Swiss. For Arabs, not even this is the case: dialects are spoken in all Arabic-speaking countries today, but Classical Arabic is still written, even in newspapers,

3 As already Olschki knew (1919–1927: 2:68).
4 They just apply sound laws to words that only exist in standard German: *Quantenmechanik* turns into /ˈkxvantəmɛˈˈxa:nikx/.

although nobody speaks it as a mother tongue. So is all contemporary Arabic literature a dead literature?

Instead of using the unclear and pejorative term 'dead', Leonhardt (2013: 19) rightly proposes calling Post-Classical Latin a fixed language instead. It certainly makes sense to distinguish 'dead' languages, knowledge of which was lost at some point and whose partial knowledge had to be recovered by scholars later on,[5] from fixed languages, which are no longer learned from one's parents and family but knowledge of which and their literature has never been lost and which continue to play important rôles in society. Among the latter, we can distinguish subforms such as liturgical languages (such as Coptic, Hebrew, Koine Greek, Latin) and fixed international languages (such as Koine Greek until the fifteenth century, Latin until the nineteenth century, or Standard Arabic until today). Leonhardt (2013: 7) points out that the trend in modern linguistics to restrict the study of language to its 'natural' form, that is, one that is oral, spontaneous, and 'untainted' by schoolmasters, is an inheritance from nineteenth-century Romanticism and is completely unscientific. The approach in the present book (as in Leonhardt's) of not distinguishing between 'dead' and 'alive' phases of Latin is an attempt to remedy this manqué 'humanist' approach. Despite being fixed, we will see below in part 3 that scientific Latin did change over time. Following Christine Mohrmann, who spoke of a 'normativisme évolutif',[6] Stotz called the linguistic development of Mediaeval Latin in general a 'fortwährende Normenentfaltung' (1996–2004: I, §9.8 =vol. 1, p. 33). In this progressive unfolding of norms, older norms remain valid (in contrast to living languages, where they are forgotten and become obsolete), but new norms may nonetheless be added. Some syntactic change happened in the Middle Ages (e.g. concerning subordinate clauses), but most importantly much new vocabulary was added to Latin's stock. Academic Latin also changed through time, but differently than a living language: there

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5 For instance, quite well for Sumerian, only piecemeal for Etruscan.

6 'Le latin a donc été une langue stylisée, une *Kunstsprache* vivante sans être la langue d'une communauté ethnique. Cette langue est vivante et variable, par suite de cette norme appliquée par les générations successives, qui n'était ni absolue ni fixe, mais qui marchait de pair avec l'évolution culturelle. Grâce à ce normativisme évolutif, le latin est devenu un instrument adéquat de la civilisation médiévale. Celui-ci, émanant de la *Ideengemeinschaft* des lettrés qui remplace la communauté ethnique, assure comme élément régulateur la vie du langage' ('Latin was therefore a stylised language, a living *Kunstsprache* without being the language of an ethnic community. This language was alive and changing, as a result of this norm applied by successive generations, which was neither absolute nor fixed, but kept pace with cultural evolution. Thanks to this evolutionary normativism, Latin became a suitable instrument for mediaeval civilisation. Emanating from the *Ideengemeinschaft* of the educated, which had replaced ethnic communities, it ensured the vitality of the language as a regulating element'; Mohrmann 1958: 273).

were no sound shifts reflected in the orthography, and hardly any change in the grammatical structure, but new constructions from within and sometimes from Greek were adopted besides, again, a lot of new vocabulary. We can thus say that Latin in the past one and a half millennia was not a dead language but (among other things) a living, although fixed, language of erudition. The linguistics of fixed languages is a field that has hardly been trodden as yet.

Fixed languages are also not 'dead' in the sense that they can, all of sudden, become fully 'alive' again, as happened with the fixed liturgical language Hebrew in the form of Ivrit in the twentieth century. Although this is not very likely to happen any time soon for Latin, Latin does not seem to be as 'dead' as one might think, even today. A quick glance at the Latin Vicipaedia shows that on 3 November 2018 it had 129,438 entries (54th among all languages in Wikipedia) with 112,290 users, although only 161 of them had made edits within the past month.[7] In early 2021, it contained nearly 4 million words, only slight less than the Perseus Classical Latin text collection.[8] The numbers for Modern Greek are only slightly higher. No other dead or fixed language comes close;[9] Sanskrit (also a fixed language of liturgy, culture, and erudition) follows with only 11,351 entries. Vicipaedia's main page has the traditional Latin *artes & litterae* opposed to *scientiae* (see chap. 1 §6 above), besides *societas*, *technologia*, and *lingua latina* as main categories. It would thus seem that the field in which Latin is still most used is that of Latin literature, science, and technology. Of course, the Latin diction used has also taken up much from the modern European languages such as English and German, the continuation of a process observed above for Jesuit Latin. Some examples of words from Vicipaedia entries: *disciplina scientifica, ethnocentrismus, societas conlaborativa, psychologia gestaltica, moratismus* (i.e. behaviourism)*, miliardum, usor* (all these terms yielded 0 hits in Corpus Corporum as of 2021). The *administratores* of Vicipaedia have to take care that the *usores* do not use 'Vulgar' Latin; indeed, the Latinity of their pages differs significantly, but they are mostly perfectly understandable. There is a warning:[10]

> *Si paginam alia lingua ac Latina exares, velut pessimae Latinitatis insignem, sive Latinitate utaris a machina confecta, noli mirari aut queri cum pagina tua deleatur.*
> 'If you write a page in another language than Latin, or one distinguished by horrible Latinity, or you employ Latin made by machine translation, you must not be surprised or complain when your page is deleted.'

7 See https://meta.wikimedia.org/wiki/List_of_Wikipedias (3 November 2018).

8 Estimated from the downloadable dump https://dumps.wikimedia.org/lawiki, counting only article text, without discussion and editing history.

9 The artificial language Esperanto has more entries, but it is spoken as a mother tongue by several thousand people by now.

10 https://la.wikipedia.org/wiki/Vicipaedia:De_Latinitate (21 June 2018).

§2 The truly great advantage Latin had to offer for science was its stability over time and its long memory[11] – advantages that Greek shared only up to the fall of Constantinople (1453). The use of the classical form of Greek diminished rapidly and for good after this traumatic event. The linguistic studies (chaps 18–20) will show that the Latin language changed very little over two millennia, that the variation is more of a stylistic nature than of a unidirectional change over time. One could say that the positive side of a language being 'fixed' is its stability. Someone able to read Varro can also read Newton's Latin (although he may not understand the maths) nearly two thousand years later. In contrast, even Newton's English is already a significantly different kind of English than ours today. If Old English or Old High German scientific texts existed, they would be very hard for us to read now. A somewhat later example may illustrate this, the German translation of the *De sphaera* of John of Sacrobosco by Konrad of Megenberg (1309–1374):

> Euclydes der maister beschreibt uns waz spera sei, und spricht: 'Spera ist ain gank ainer ůmbverte ains halben kraizzes, deu veste und eben stet an irr mittelmezzigen lengen und di man also lang umbfůrt piz sie wider kůmpt an die stat irs anvanges.'[12]
> *Spera igitur ab Euclide sic describitur: spera est transitus circumferentie dimidii circuli quotiens fixa diametro quousque ad locum suum redeat circumducitur.*[13]
> 'A sphere is thus described by Euclid: a sphere is the orbit of the circumference of a half circle having a fixed diameter when it is led around until it returns to its initial position.'

In the mere half-millennium between Konrad's times and ours, his German has become very hard to read for German-speakers. Some of the problems that arise are orthographic, but the more serious ones concern vocabulary: 'mittelmezzige lenge' is now called *Durchmesser*; 'die stat', *Ort*. By contrast, Sacrobosco's Latin is still close enough to Cicero's that the latter would have understood it easily (although probably disdaining its style). Thus, Antoine Meillet was spot-on when he pointed out (1928: 1):

> Langue d'un grand empire [...] le latin à gardé durant quelques huit cents ans une stabilité. Quand l'unité de la langue parlée a commencé à se rompre, du IIIe au Xe siècle ap. J.-C., l'unité de la langue écrite à persisté. Le latin classique est demeuré jusqu'à une période

11 This advantage was obvious to many writers before the nineteenth century. Samuel Gott addresses the three old holy languages (Hebrew, Greek, Latin) in book III of his novel *Nova Solyma*: *In his, tanquam tot preciosis arculis omnes artium et scientiarum gemmae conduntur* ('In these languages, as if in as many precious caskets, all jewels of art and science are stored'; 1648 edition, p. 132).
12 *Deutsche Sphaera*, ed. Matthaei, p. 4.
13 Edited in Thorndike (1949: 76).

avancée de l'époque moderne l'organe de la science et de la philosophie dans l'Europe occidental.
'As the language of a great empire [...] Latin kept its stability during some eight hundred years. When the unity of the spoken language began to break down, from the third to the tenth century AD, the unity of the written language persisted. Until late modern times Classical Latin remained the organ of science and philosophy in Western Europe.'

The argument that Latin's status as a 'dead' language actually benefited it in its rôle as language of science because the language was no longer suffering erosion by linguistic change and remained intelligible and usable as a kind of meta-language,[14] was already used in the time when Latin was fighting to retain but finally lost this rôle. Of course, this was already clear to the more thoughtful early modern authors. For instance, Baltasar Gracián, SJ, addressed Latin in 1651 as *eterna tesorera de la sabiduría* ('the eternal treasurer of wisdom'; *El criticón* I.4, ed. Romera-Navarro, vol. 1, p. 164). When this state of affairs is no longer taken for granted and the discussion of the continued use or abolition of Latin in the sciences is taken up, this point is also often stressed; for instance, Renatus Carolus de Senkenberg (*Meditationes maximam in partem juridicae quinque,* p. 139) pointed out in 1789:

Mortua quum sit [lingua latina], id est nulli amplius populi propria, sed communi tantum eruditorum consensu talis, qualem Romani scriptores nobis reliquere, pro lingua scientiarum adoptata, nullis haec mutationibus obnoxia est. Ergo omnia substantiva, omnia verba, omnia vel minima vocabula, eandem post mille annos, modo non plane exulare tunc jussa sit, apud ejus peritos habebunt, quam nunc et quam ante bina jam millia annorum habuere, significationem.
'The Latin language being dead, that is, no longer the property of any nation but only through mutual consent of scholars adopted – as the Roman writers left it to us – as the language of the sciences, it is not subject to any changes. Thus, all nouns, all verbs, all words, even the slightest – provided that Latin will not be abolished altogether – will have for those versed in it the same meaning in a thousand years as today, and as they already had two thousand years ago.'

§3 Latin had taken over the function of being Europe's language of science and learning from Greek and was succeeded by several European vernaculars; we might speak of a *translatio linguae*, comparing it thus to the mediaeval concept of *translatio imperii* (Pörksen 1999: 649). Some of Latin's heirs – and, one is tempted to say: murderers – were already encountered above (chap. 14 §§3, 6), especially French. After the initial success of French as the sole international language in the eighteenth century, three languages soon ended up replacing Latin as the

14 See Glei (2014).

languages of science throughout the nineteenth century: French, German, and English (Gordin's 'triumvirate'). Somewhat earlier, Italian[15] started to be used for scientific publications, but this was not to last long, as a look at the languages in the list above (chap. 14 §3) shows. In the early twentieth century (after World War I and the exclusion of German scientists from international scientific conferences for eight years), English started to ascend to world hegemony, which (at least in the natural sciences) is today all but complete, as can be seen in Ammon's graphic (fig. 29). The curves show how only German between the Wars and then Soviet Russian were able to briefly challenge English after the break-up of the 'triumvirate'. Latin is not even depicted any more.

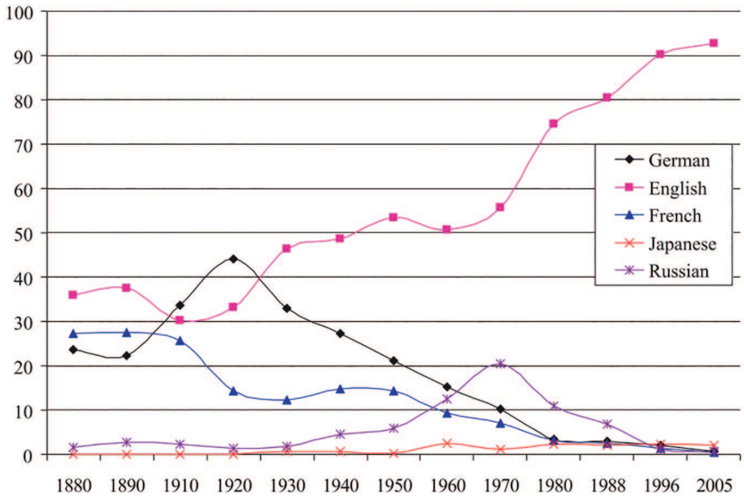

Fig. 29: Source: Ammon (2012: 338). The values are given as percentages and are based on the natural sciences worldwide, from Biological Abstracts, Chemical Abstracts, Mathematical Reviews, Index Medicus and Medline, and Physics Abstracts.

Latin as the language of the sciences had some clear advantages, especially its ready-made vocabulary and syntax for scientific use, but most of all its international comprehensibility.[16] Leibniz called it the *lingua europaea universalis et durabilis ad posterioritatem* ('the European language that is universal and durable for posterity'; 1872a: 441),[17] and would have liked to see it preserved at universi-

15 For which see Olschki (1919–1927).
16 For a list of advantages and disadvantages, see Pörksen (1986: 69–71), besides Roelli (2018).
17 He points out in parentheses: 'zumahl da die lebenden sprachen veränderlich seyn' ('especially as the living languages suffer change').

ties. The three new languages of science (German, French, English) are all Indo-European languages with a similar structure and heavily indebted to Latin (and more indirectly to Greek). This made it relatively easy for them to adopt and to share the position of language of science, as any scientist with a decent education could be expected to read all three languages. A brief look at how these three vernacular languages acquired the necessary vocabulary and syntax concludes this part of the book. How their vocabulary had to adapt is discussed in more detail in chapter 21.

Scientific vocabulary

§4 As soon as the vernacular languages start to be used for scientific matters, technical terminology from Greek and Latin is quite naturally taken over. Chaucer's (ca. 1343–1400) *Treatise on the Astrolabe,* which he proudly wrote in his mother tongue, not in Latin, can still not avoid the use of Latin and Arabic terms (underlined), as this example shows (part II, §6, ed. Skeat, p. 20):

> To knowe the spring of the dawyng & the ende of the euenyng, the which ben called the two crepusculus: Set the nadir of thy sonne vp-on 18 degrees of heyhte Among thyn Almykanteras on the west side; & ley thy label on þe degre of thy sonne, & thanne shal the poynt of thi label schewe the spryng of day.

But the extent of this can be much greater still, and may include phrases and syntax. Pörksen (1994b) speaks of *Fachwerkstil* ('timber-frame style') for what often ensued, that is, texts that although written in a vernacular language are interspersed with Latin, not only Latin words (which is to some extent still true today of much scientific English prose) but also phrases and entire sentences. An example from Leibniz (1872a: 439):

> Ein Studiosus Medicinae, ob er schohn bloß ad praxin gehen will, soll neben denen communibus omni studioso dignis guthe kundschaft haben in mathesi practica et physica generali, auch deneben herbas medicinales vel officinales umd andere materialien kennen lernen, die bey den Apothekern und materialisten gebräuchlich.
> 'A *studiosus medicinae*, even if he only wants to go *ad praxin*, should, in addition to the *communibus omni studioso dignis*, have good knowledge *in mathesi practica et physica generali*, as well as getting to know *herbas medicinales vel officinales* and other materials used by pharmacists and purveyors of remedies.'

One of the main reasons for Latin's long persistence in a time of vernacular tongues vying for European hegemony was clearly its terminology. In many sciences, it already had a vast stock of Greek and Latin terms inherited from Antiquity, which was often considerably enlarged in scholasticism and during the heyday of the Scientific Revolution. Besides this advantage, among the new contestants for becoming scientific languages, only German had the ability to effortlessly form new words by compounding. This flexibility, on the other hand, had the disadvantage that often several different attempts to render one Latin term coexisted. For instance, German writers from Notker Teutonicus (ca. 950–1022) to Wolfgang Bütner (ca. 1530–ca. 1596) translate *subiectum* variously as *underin*, *Vordertail des Fürschlags*, *Subjectum*, *Grundwort*.[18] Thus, Germans had no problem forming new words, especially compounds, to render Latin concepts; the problem was only one of standardisation. Even in the seventeenth century, it will have been much easier even for educated Germans to understand standardised Latin than scholarly German authors in many fields. So, for sciences with a need for a vast and growing vocabulary, it was still Latin that offered the best solution as late as the eighteenth or even the nineteenth century. Good examples of this are botany (chap. 15 §4) and chemistry, which still uses abbreviations of the Latin names of chemical elements (chap. 21 §7 below). Medicine could also be mentioned in this respect.[19] In order to gain the necessary vocabulary, the Romance languages and English naturalised Latin and, to a lesser degree, Greek terms from the Latin scientific literature by submitting them to some simple sound-change laws and adapting their pronunciation. German did/does this partly as well, but often translates the Greek or Latin terms into German compounds.[20] Indeed (Pörksen 1999: 645):

> Die deutsche wissenschaftliche Prosa hat sich nicht auf der Grundlage einer eigenen untergründigen mündlichen Kultur herausgebildet, sondern als Lehnprägung der lateinischen Schriftkultur.
> ‘German scholarly prose did not develop on the basis of its own underlying oral culture, but rather as a borrowed formation from Latin written culture.’

The entomologist Theodore H. Savory observed that contemporary scientific language can be very easily translated, as illustrated by an example of a short entomological text he translates very closely from French to English, shown in figure 30. This observation is interesting, although it will become clear (chap. 22) that this can only work if scientists in both languages share the science in question and have established a one-to-one correspondence between terms – today, espe-

18 See the table in Schmid (2015: 45) with a dozen or so similar examples.
19 See also Dirckx (1983).
20 Many German non-scientific terms are also clearly calqued from Latin, but this is no longer recognised by speakers, e.g. *Barmherzigkeit* = *misericordia*, *Einfluss* = *influentia*, *Eindruck* = *impressio*, *Zufall* = *accidens*, *Allmacht* = *omnipotentia*, *unbegreiflich* = *incomprehensibilis*, *ausdenken* = *excogito* (see Wiegand 1999: 642).

cially when they share the general *Begriffsgemeinschaft*. All of this is the case here, as most terms are of Greek or Latin origin (‘arthropod’, ‘chitinous’,[21] ‘ecdysis’, and so on). Moreover, both French and English developed their scientific language out of Latin. But the situation is very different for languages that do not take over concepts easily (see chap. 23), or that do not (yet) share the *Begriffsgemeinschaft* – for instance, for Arabic translators from Greek in the Middle Ages. Thus, this easy translatability of scientific language is largely illusory. Besides vocabulary, one-to-one syntactic correspondences are also crucial to transplant a science from one language to another.

Chez plusieurs animaux le rapport entre les mues et la croissance prend une forme mathématique intéressante. Chez les arthropodes la croissance linéaire entre les mues est gênée par l’enveloppe chitineuse rigide alors que l’augmentation de poids continue à se faire. Au moment des mues, l’organisme se débarrasse de la trop étroite enveloppe, une autre plus conforme à son poinds la remplace, et l’animal s’adapte rapidement au nouveau régime. Przibram et Mégusar ont admis que le poids des arthropodes devait doubler d’une mue à l’autre, ce qui correspondrait au dédoublement de toutes les cellules du corps. Par conséquent, les dimensions linéaires devraient s’accroître d’une mue à l’autre à raison de $\sqrt[3]{2} = 1{\cdot}26$.

In many animals the relation between moulting and growing takes an interesting mathematical form. Among arthropods linear growth between moults is prevented by the rigid chitinous skeleton, while increase in weight continues to occur. At ecdysis the animal rids itself of its tight skin, another more suited to its weight replaces it, and the animal quickly adapts itself to the new régime. Przibram and Mégusar supposed that the weight of an arthropod should be doubled between one moult and the next which would correspond to a doubling of every cell in the body. In consequence linear dimensions should increase from one moult to the next in the proportion of $\sqrt[3]{2} = 1{\cdot}26$.

Fig. 30: Perfect translation of scientific language? From Savory (1953: 116–117). Line 8 in the French text has a typographical error: *poinds* should read *poids*.

Syntax

§5 Syntactic borrowing in the Western European vernaculars from Latin was probably considerable, but the field is understudied.[22] Blatt (1957: 69) concluded about syntactic borrowing:

> These two features taken together, viz. the architecture of the sentences or phrases and the rationalisation of the language, suffice to prove that Modern European syntax bears the stamp of the Latin genius. European standard languages of to-day may be considered useful instruments for modern thought, because tuned from Classical syntax.

21 This substance’s name is ultimately derived from χιτών (‘garment’).

22 Beckman (1934) made a start but remained on the quite general level of matters like the emergence of words for ‘yes’ (14) or ‘one’/*man*/*on* (15). Pörksen rightly wonders: ‘Warum gibt es keine Geschichte vom Übergang vom Lateinischen zum Deutschen?’ (‘Why is there no history of the transition from Latin to German?’; 1999: 644).

In the case of German, more infinitive and participle constructions, hypotaxis, and more complex sentences have been named as emerging under the influence of Latin.[23] It also seems that the modern Western European languages took over some absolute constructions from Latin. We shall confine the discussion to one example of a potential borrowing that works in English but not in German.[24] English can form -ing-form or passive participle clauses that resemble the Latin *participium coniunctum* and the *ablativus absolutus*. Thus, one can say:

> This substance, discovered almost by accident, revolutionized medicine.[25]

This corresponds exactly to Latin (translating verbatim):

> *Haec substantia, inventa quasi fortuite, medicinam novavit.*

The English substitute for the *ablativus absolutus* is sometimes called a 'nominative absolute'. It can be traced back to a 'dative absolute in disguise', which was common, for instance, in Wycliffe (ca. 1325–1384).[26] A modern example:[27]

> No further discussion arising, the meeting was brought to a close.

This corresponds to Latin:

> *Disputatione absente, conventus terminatus est.*

It seems that this construction becomes fully naturalised in English only after 1660, at first in authors with classical influence.[28] This cannot be done in German or in French; both languages require a construction with a finite verb form. But Old High German had a similar construction (also with the dative) which was sub-

23 Habermann (2001: 33–57). Von Polenz (2000: 219), surprisingly, estimates the Latin syntactic influence on German as minor.

24 The Romance languages have similar constructions: *Questa sostanza, scoperta quasi per caso, rivoluzionò la medicina*, or *cela étant dit*, although this would not be used to translate the 'No further discussion arising …' example below.

25 From Quirk et al. (1985: §15.61, pp. 1124–1125), who speak of 'subjectless supplementive clauses' and note that this also works without a participle: 'I found George, unconscious, a few hours later.'

26 See Ross (1893: 302).

27 Also from Quirk et al. (1985: §15.58, pp. 1120–1121), who speak of 'absolute clauses'.

28 Thus Ross (1893: 302).

sequently lost: *bî fatere lebendemu* = *patre vivente*. Modern German tends to use nominal construction for similar cases: *zu Lebzeiten des Vaters*.

§6 Science in the vernacular, of course, brings with it both advantages and disadvantages. With vernacular science, influence on popular culture is augmented dramatically (for good and for ill); it can be abused in nationalism; the texts may become unintelligible beyond national borders, which again favours a nationalist group identity and the formation of national schools; and its terminology may waiver between technical meanings and everyday ones. On the other hand, more people gain access to erudition, and new ways of practising science may become easier outside the old Latin framework. Vernacular prose certainly also profited from this influx from the sciences. As mentioned above, the inherent stability of a fixed language that had long ceased to be spoken by a people and had thus become common property is the most important point in favour of the continued use of Latin. Latin was still the only medium when the important changes of the Scientific Revolution happened; this revolution might not have happened at all in a linguistically fragmented Europe that became the norm in the nineteenth century. However, as far as the kind of science is concerned, I cannot discern a significant change in methodological *Denkstil* in the eighteenth and nineteenth centuries:[29] the vernaculars carry on the Latin kind of science developed in the Scientific Revolution, even copying its language, especially the terminology, considerably. The revolutionary science we still practise today seems to have remained faithful to its Latin foundations in the Scientific Revolution.

29 In contrast to Pörksen (1999: 657).

Part 3 Changes in the language of science

This third part of the book undertakes several linguistic forays into largely uncharted territory about the Latin of science and learning. Various methods will be used, but especially corpus linguistic ones. In particular, this is the first attempt to linguistically study scientific Latin from its beginnings to the present; texts from the authors introduced in part 2 will be used to this end.[1] Data for scientific Latin will be mined from Corpus Corporum, first by studying one large general scientific corpus (chaps 18–19), then several smaller specific ones (chap. 20) diachronically and comparing the results to several corpora of other Latin prose. With the help of these corpora, the goal is to find out (i) to what extent scientific Latin differs from other Latin, (ii) to determine whether there are trends of change through time, and (iii) to identify different types of Latin scientific writing. Then, progressively more general topics are addressed: differences in naming novelty in science between Antiquity, scholasticism, and modernity in Latin (chap. 21), a comparison of Latin with some other traditional languages of science and their translatability (chap. 22), and the reuse of Greek and Latin in the modern languages of science (chap. 23). The last chapter (chap. 24), finally, attempts a synthesis of how science, culture, and language interact and of how far the Greek scientific *Denkstil*

1 Banks (2008) did something similar for scientific English: from Chaucer to present-day usage.

depends on the Greek language and how it could be transplanted into Latin, whence it led to modern science. It is hoped that these approaches will produce an initial overview upon which further research can build.

17 Introduction to the linguistics of scientific language

§1 Above (chap. 4), linguistic prerequisites for a language of science were postulated. Its vocabulary should, it was suggested, (i) have a well-defined terminology, (ii) be unambiguous for specialists, and (iii) display extendability/flexibility, and its syntax should demonstrate (iv) perspicuity and (v) evidentiality, such as nuances of certainty. In general, the syntactic structures available in a language of science should represent the topic under consideration adequately, for instance by representing clearly the kinds of relations between the objects studied by the science in question. Structure words (conjunctions, prepositions, particles, the article) are especially important for achieving this. In general, we might ask whether the parts of speech follow different distributions in technical scientific Latin than in other registers. How did their use change diachronically in Latin? How do they compare to other languages of science?

This introductory chapter will review some findings from the study of modern scientific language; especially for English and German, quite a lot of work has been done in the preceding decades. These insights will then serve as a point of departure for studying scientific Latin. We would expect to find some similarities, or at least a general trend converging toward contemporary practices, between these Latin results and those for modern scientific English and German. Differences in vocabulary and syntax, especially parts of speech, in scientific German and English are reviewed first.

Vocabulary

§2 According to Gerr (1942), the evolution of a language of science consists of three elements: (i) increasing size and complexity of vocabulary, (ii) rationalisation of the vocabulary through multiplication of functional and operational terms, and (iii) general rationalisation, that is, the progressive reduction of syntactic complexity to the absolute minimum. Point (iii), however, may only apply to the contemporary English of the natural sciences and may not be typical at all. Special vocabulary, point (i), is certainly the most conspicuous characteristic of scientific language in general. Indeed, technical languages or languages for special purposes (*Fachsprachen*) have hitherto mainly been studied in terms of specialised vocabulary, which, in turn, is often claimed to consist

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especially of nouns.[1] 'Langues techniques' were described by Vendryes (1921: 294–295) as:

> Les langues techniques sont dues à la nécessité de désigner des objets ou des notions qui n'ont pas de nom dans l'usage courant; mais elles répondent aussi au besoin de désigner 'scientifiquement', c'est à dire par un terme plus précis, excluant toute équivoque, des objets que désigne fort bien la langue ordinaire.
> 'Technical languages arise due to the need to designate objects or notions which do not have a name in everyday use; but they also respond to the need to designate "scientifically", i.e. by a more precise term, excluding any ambiguity, objects which are already designated in ordinary language.'

He then compares technical languages to argot, jargon, and cant. These varieties of language have in common the fact that they are most distinctive in their technical vocabulary. Langslow defines technical terminology thus (2000a: 25):

> A referring expression which is recognized and used in a standard conventional way by the relevant community of specialists and which unambiguously (and often uniquely) names an object or a concept of the discipline, and therefore, because of this attachment, tends itself to absolute synonymy and total translation.

We have already pointed out (chap. 16 §4) that such total translation is in general illusionary: it works only if the two languages in question share a scientific approach and a *Begriffsgemeinschaft*. If one is dealing with less 'abstract' topics, as Langslow does in medicine, it may be enough to merely label a sensibly perceptible 'object' shown by ostension and apply a name (a bone, medicinal plant, disease, etc.), or to define a translation for such a label from another technical language (in the case of Antiquity, Greek). This makes the use of technical vocabulary in medicine, for instance, much more straightforward than in more abstract sciences such as physics or even more 'philosophical' fields such as logic or linguistics. Here, complex thoughts and often new not sensibly perceptible items are met and stand in need of words that make sense only within the system of thinking (Fleck's *Denkstil)*. Some examples: 'work', 'force-field', 'significant error', 'metabolism', and so on. If a science is strongly formalised, especially mathematically, which becomes common for some sciences only after the Scientific Revolution, this becomes much easier (e.g. work: $W = \int F\, ds$). This explains why 'total translation', as demanded by Langslow, was, in fact, not at all trivial. For instance, the first mediaeval translators of Aristotle's *Physica* and *Metaphysica* had to deal with a very difficult task.

1 e.g. Langslow (2000a: 6–7).

In general, there seem to be two phases in the development of the terminology of a scientific branch: a groping in a new field, accumulating facts, then a cleaning-up of terminology once a certain standard approach and understanding have been gained. Sager, Dungworth & McDonald put it thus: 'only when a sufficiently large body of knowledge has been accumulated, can an attempt be made to order it systematically and to reflect this ordering in regular patterns of designation' (1980: 239). In medicine and biology, this led to the contemporary quasi-artificial language based on Greek and Latin; in chemistry, a special body (IUPAC) defines rules for naming chemical compounds. But completely new substances, such as toluene, are still named arbitrarily.[2] Further examples are mentioned below (chap. 21 §5).

Sager, Dungworth & McDonald (1980: 242) found that scientific vocabulary consists of (i) general language words ('note, observe, prove'), (ii) general language words used specifically with some restriction or modification of meaning ('segregate, precipitate, current'), and (iii) specialist terms usually only used by specialists ('to age a dye, conversational device'). Such specialised terms can generally be formed by three methods (245): (i) creation within the language (suffixes, compounds, …), (ii) extension of meaning, and (iii) borrowing from outside. In comparison to other Indo-European languages such as Sanskrit, Greek, or German, compounding is less common in Classical Latin – it is even quite consciously avoided – but suffixation does play an important rôle both in scholastic Latin and in English, in fact with many suffixes from the former in the latter ('-ise', '-ous', '-ent', '-al', '-ic', '-ation', …).[3] English does use the equivalents of compounds quite freely, but they tend to be considered noun phrases as they are rarely written as a single word. They can get nearly as long as in German in scientific English, for instance 'fluid power transmission system' (273).[4]

Some examples of scientific neologisms illustrate several ways in which they can be formed in English (281): by combinations of Greek or Latin word elements (such as 'dictaphone'), Latin or Greek stems (such as 'cusp', 'apex'), blending, compression of existing terms (such as 'transceiver' < 'transmitter' + 'receiver'), eponyms (such as 'Mach number'), and use of letters (often Greek, such as 'gamma ray'); absolute invention, however, is rare (such as 'byte', 'paraffin'). Below (chap. 21), we will study examples from medicine of the formation of Latin scientific vocabulary. Sager, Dungworth & McDonald (chap. 9)[5] also provide numbers

2 Although toluene could be called methyl benzene, and benzene itself [6]annulene, but terminology becomes too long like this and is avoided.

3 Sager, Dungworth & McDonald (1980: 298–300) offer a list of English scientific suffixes.

4 On English compounds, see Marchand (1969).

5 This standard work will provide us with figures for many parameters below.

showing how far technical terminology can be developed. For instance, in 1980 there were more than 4 million names in organic chemistry. Although many constituents of them stem from Latin- and Greek-based words or parts of words, this special vocabulary has its own complex rules of derivation, enabling chemists to understand most of these artificial words without having heard them before. For instance, someone who knows ‘toluene’ will also understand ‘trinitrotoluene’.[6]

Syntax and parts of speech

§3 The distribution of parts of speech (PoS) in technical languages can differ significantly from ordinary language.[7] Below, it will be seen that this is also true for scientific Latin. For English, Sager, Dungworth & McDonald (1980) provide some numbers: nouns account for 28 % of words in general English, but 44 % in scientific English; on the other hand, adverbs seem to be less frequent (4 % vs 8 %; 234). Conversely, a study by Alekssev (cited ibid.) also found verbs to be rarer (full verbs 9.6 % vs 15.8 %, auxiliaries 6.9 % vs 11.9 %) when he compared the language of electronics to ordinary telephone conversations. Articles were more common in scientific language (12.8 % vs 7 %). In contrast to Latin and Greek, English (like Chinese) can very easily convert PoS (244), that is, use one word category for another. But unlike Chinese, English also borrows very easily. All of this together makes English quite unique among the major languages, and scientific English, a mixture of constituents from many sources, even more so.

PoS distributions can also be telling regarding syntactic differences, especially the percentages of structure words, which will be studied for Latin below. There is less literature about syntactic differences between ordinary and scientific language than about vocabulary. Quite in general, specialised languages tend to make use of already existing syntactic devices, although possibly fine-tuning them and using them in different frequencies. Gross, Harmon & Reidy (2002: 230) summarise their study and describe scientific syntax as follows:

> In the 20th century, we find the scientific article growing considerably more uniform across national boundaries and scientific disciplines. Most striking of all, ‘scientific English’ has become the international discourse of science, which involves not only a specific language but also a suite of stylistic features: relatively short, syntactically simple sentences containing complex noun phrases with multiple modification, verbs in the passive voice, noun strings, technical abbreviations, quantitative expressions and equations, and citational

6 Chinese characters are somewhat similar in this respect: sometimes it suffices to understand their constituent parts to guess a character never seen before. Of course, in chemistry the system is much more logically stringent.

7 For this section, see Sager, Dungworth & McDonald (1980: chap. 8).

> traces. French and German scientific articles also conform to this basic style, with some variations. For example, French and German scientific prose has resisted the noun string; each of these languages employs several grammatical structures that avoid the passive voice yet maintain an objective tone. Whatever the language or discipline, the style is streamlined to focus the reader's attention on the things of the laboratory and the natural world beyond the printed page, rather than to draw attention to the text itself or its author.

Similarly, Gerbert (1970)[8] already found that typical features of scientific English syntax are 'high density of nominal groups, usually heavily modified, a large number of non-finite verb forms and extensive use of the passive'. On the other hand, one is unlikely to encounter idioms (but not jargon), colloquialisms (such as 'isn't', 'gonna'), or the personal pronoun 'I' (although 'we' is frequent; it may be used for a group, a member of a society, anyone, the reader – 'as we shall see later' – or the reader and the author; Sager, Dungworth & McDonald 1980: 226–227). So the first person singular is rarer than in most other types of writing. Indeed, the third person is by far the most common one. Banks (2008: 197) finds low numbers for the first person singular through the entire timespan of his study (eighteenth to twentieth century) in English.

It would seem that the use of prepositions and conjunctions, which determine the relationship between words and clauses and which may be used to model those between processes and entities, is especially important in scientific writing.[9] Declarative sentences are indeed frequent; logical connections between thoughts are often expressed by conjunctions such as 'consequently, hence, so, therefore, thus', 'as a result of, because of, in view of, owing to', and so on (Sager, Dungworth & McDonald 1980: 186–202, here 190, 191). Sentences are often explicitly linked together by particles such as 'such, this, these; consequently etc.; additionally, in addition, besides, for example, for instance, furthermore, likewise, moreover, similarly, then; conversely, however, nevertheless, otherwise; as follows, following, below, later' (198–200). As science often deals with the relation between things, prepositions are clearly also important. For prepositions, Poncelet (1957) tried to show that Greek's richness was hard to reproduce in Latin, especially in Classical Latin that of κατά ('according to') to express conformity (in scholasticism, *secundum* was to take its function).[10] Complex prepositions – those consisting of several words, such as 'in respect of' – can usually be added to a language's repertoire easily. Gowers, Barrow-Green & Leader (2008a: 10–13) point

8 Quoted in Sager, Dungworth & McDonald (1980: 184–185).

9 In strongly inflecting languages, cases can take on such rôles as well; see, for Sanskrit, Jacobi (1970).

10 *Quoad* can take similar functions (Lewis & Short's last meaning: '[w]ith respect to, as to, = *quod attinet ad*'), but it too was rare in classical times.

out that mathematical functions can be seen as having the same rôle as prepositions in natural language. Thus, 'the cat is under the table' corresponds to 'five is the square root of twenty-five'; mathematical equivalence relations can similarly be compared to conjunctions. Or, put differently: modern mathematics in a sense generalises and formalises conjunctions and prepositions found in natural languages.

Among verb forms, imperatives are frequent in some technical writing (such as manuals), but not in strictly scientific texts. On the other hand, the verb 'to be' is in general particularly frequent. 89 % of all tenses are simple present (64 % active, 25 % passive), the remaining 11 % mostly present continuous active and passive and simple future. Earlier studies found percentages for the passive voice in science to be 32.6 %, 28 %, 26 %, 26.3 % (Sager, Dungworth & McDonald 1980: 209), thus between a third and a quarter.[11] In literary works, they are much lower: only 2.2 %, or in drama 3 % (206). The reason for this seems to be that the focus is on the result, not on the subject. The passive voice also allows the result to be placed more prominently before the verb and permits shorter formulations: 'density was measured' vs 'the experimenter (or: we) measured density'. Banks (n.d.: 13–14) confirms these numbers (30.6 %) and shows that this predilection for the passive voice is noticeable from the early nineteenth century onward. It has often been claimed that this is due to a wish to have the texts look impersonal and 'objective',[12] but the above explanation to put the object of study rather than the scientist himself into thematic and emphasised position seems more plausible.[13] French, German, and Russian can also use reflexive verbs and impersonal active clauses (German *es*) similarly; English only has the impersonal 'one', which easily sounds awkward. Turner (1962: 181–197) claimed that the high incidence of the passive voice goes back to Mediaeval Latin, providing examples from Frederick II's book on falconry (182). He concludes: 'The scientific paper [...] inherited the passive from general English and from science Latin, but had to develop characteristic uses of it' (183). On the other hand, Banks (2008: 100) shows that between the eighteenth and twentieth centuries in English scientific papers (both in physics and in biology) numbers for the passive voice rise from roughly one-fifth to more than one-third of all finite verbs. Thus, it is not so clear whether this feature

11 Banks (2008: 99–111) similarly finds between 7 % and 50 % of all finite verbs in the passive mood. The averages are around 30 %, with some differences between texts on physics and biology. Similar numbers in Banks (1990: 14–15), for a corpus of eleven oceanographic English papers; I calculate from his table 32.16 % ±6.27 %, although in the sections describing the experiments the numbers were even higher: 52.5 %.

12 e.g. by Quirk et al. (1985: §3.73, p. 166).

13 So also Banks (2008: 140).

stems from Latin or developed only recently within English. Numbers for Latin scientific texts will be evaluated below and show that there is, indeed, a higher incidence (chap. 18 §4), although less strongly: 12.8 % of all verb forms are third person passive, in contrast to 9.1 % in non-scientific texts; in poetry, by contrast, the numbers are much lower (4.6 %).

Among modal auxiliaries, those indicating possibility are especially common (Sager, Dungworth & McDonald 1980: 210): ‘can’ and ‘may’ usually for possibility, ‘will’ for future and prediction. Non-finite verb forms are more common in science (212–215): 35 %–39 % of verbs were found to be non-finite, compared to only 17 % in drama. One study found 19 % infinitives, 34 % past participles, and 47 % -ing-forms among non-finite verb forms; another 37.7 %, 26.9 %, and 35.4 % respectively. ‘The chief characteristic of the -ing form is its grammatical flexibility. [...] [which] makes it extremely popular with specialist writers’ (215). It can be nominal (‘rust proofing’), stand after prepositions (‘by considering’),[14] be used as an adjective (‘operating cycle’), appear in clause reduction (‘The E and B fields satisfying the Maxwell equation in free space’), express result (often after ‘thus’, ‘thereby’), or form detached non-finite clauses (‘Radioactive decay is a true first order process, the rate of decay depending only upon [...]’; often introduced by ‘with’ or ‘thus’). This last-mentioned usage combines clarity and conciseness, which are important for economy of expression. Clause reduction and detached non-finite clauses can be achieved in Latin using the *ablativus absolutus,* but these English clauses can be used more generally. Below, it will become apparent that non-finite verb forms are not more common in scientific Latin.

An important feature of modern English scientific language is what Banks (n. d.) calls ‘hedging’, that is, ‘reducing the strength of what’ someone ‘is writing’ (104), especially by means of adverbs (110) such as ‘probably, generally, possibly, perhaps, apparently, conceivably, presumably, significantly, reasonably, usually’. This is comparable to our criterion (v), evidentiality or modalities, for scientific language. For English, the number of words per sentence has sometimes been used as a measure of syntactic complexity.[15] Unfortunately, this is a quantity that is not well defined for pre-print Latin, and cannot be used.[16] But indicative vs subjunctive can be measured, as a broad indicator of main and subordinate clauses. Numbers are presented below: they differ significantly from other Latin prose only for some scientific texts, especially scholastic ones.

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14 After, in descending frequency, ‘by’, ‘of’, ‘in’, ‘for’, ‘on’, ‘after’, ‘before’.

15 e.g. by Banks (2008: 68).

16 Antiquity used no or very different punctuation, and mediaeval manuscripts used their own systems of punctuation. Punctuation in editions is largely the editor’s and depends strongly on his nationality and taste.

Noun phrases and compounds are also often mentioned as typical for scientific English. Quirk et al. show the high frequencies of noun phrases in scientific writing, especially of non-subject, complex ones.[17] Sager, Dungworth & McDonald (1980: 219) point out that

> nominal groups are the most appropriate vehicles of condensed linguistic expression for scientists and technologists who are trained to perceive and consequently to speak about the physical world in terms of concepts, processes and quantifiable units.

In scientific English, there are many possibilities for modifying noun phrases: (before the clause) verbless or -ing clauses, predeterminers (such as 'all'), determiners (articles, demonstratives); (after the clause) adjectives, prepositional phrases, non-finite clauses, relative clauses, nominal apposition, adjectival phrases ('equal to').[18] Banks (2008: 63) found that nominalised processes in the English translations of Newton's works are directly derived from Latin. The method by which an action is carried out can be described using -ing-forms or relative clauses. Result or purpose clauses introduced by 'in order that, so that, such that', adverbial clauses introduced by 'as, because, when, since', and conditional clauses ('if, then') also abound. Sager, Dungworth & McDonald (1980: 222–224) speak of 'one-way communication', i.e. no dialogues, no questions other than rhetorical ones, and so on. Relative clauses with a relative pronoun at their head also seem to be more common in science than in ordinary speech. In English, active relative clauses can be reduced to an -ing-form (without relative pronoun), unlike in German, French, Russian, Latin, or Greek.[19]

English is not very helpful for studying the use of cases (excepting the genitive, which alone has kept its own form). For German there seem to be no available data on the percentages of genitives or nominatives, which would a priori seem to be the two cases most likely to be more frequent in scientific writing. Nominal phrases with the genitive are a prominent feature in the German scientific texts studied by Brommer (2018: esp. 6.1.1.2).

17 Quirk et al. (1985: §17.123, p. 1350); their example is: 'At the mouth of the respiratory tube is *a series of velar tentacles, corresponding exactly in position to those of amphioxus, and serving to separate the mouth and oesophagus from the respiratory tube while the lampre is feeding*' (italics in original).

18 More on such impersonal constructions in chap. 22 §7 below.

19 But a similar construction exists in Arabic: it is possible to form indefinite relative clauses without the relative pronoun, e.g. 'he is a man who works in a factory' = 'he is a man working in a factory', in Arabic *huwa rağul allaḏi yaʿmal fi masnaʿ* = *huwa rağul yaʿmal fi masnaʿ*. For this construction, see Badawi, Carter & Gully (2004: 489).

In summary, we can conclude that the following features are especially conspicuous in scientific English today: the use of -ing-forms, prepositions and conjunctions, the passive voice, a lack of the first person singular, and the nominalisation of processes. We can concur with Sager, Dungworth & McDonald (1980: 277): ‘Special languages are able to compress information both syntactically and lexically.’ The next two chapters will test how much of this is also true for Latin.

18 Linguistic development studied in a general scientific corpus

§1 Using the Corpus Corporum Latin language full-text collection, large amounts of data can now be processed automatically very quickly and reasonably correctly. Starting from what was described for scientific English in the previous chapter, this chapter tries to find similar characteristics of scientific Latin and to determine whether they have changed over time. At least to some extent, the development will also be considered from the other side: what features of scientific Greek were imported into Latin? As a a comparison set, some diachronic benchmark data for normal (non-scientific) Latin prose are produced first. For the scientific texts, forty of the Latin prose texts discussed in part 2 of this book from different fields and times were chosen. As a potentially interesting out-group, four translations from Greek are included, among them a non-scientific text, the Vulgate version of the New Testament. The idea is to first find characteristics that set all (or most) of the scientific texts apart from the benchmarks, and then to try to group them and to find different scientific Latin styles within them. For this, principal component analysis (PCA; see §6) will be used. This first relatively heterogeneous sample of forty texts was chosen in order to spot general trends; it will be compared to more homogeneous samples in chapter 20, which studies scientific Latin texts from some well-defined fields. Anyone familiar with such texts will know that different scientific styles or registers do exist in Latin, so one would expect them to be detectable quantitatively.

One might doubt whether much diachronic change will be detectable, given that the Latin language became fixed in the time of Cicero to such an extent that its written form stopped developing further according to normal language development and was petrified as a *Hochsprache* for the two thousand years to come (chap. 16 §1). Indeed, we can hardly expect scientific Latin to change in a clear manner through time. But as Latin did take up new words and constructions through these two millennia while retaining the older patterns, it is likely that new styles of writing emerged over time; these will be discussed in the next chapter (chap. 19). Besides, as Latin has a deep memory, it may be expected that old registers of scientific writing will be found to reappear again over time in some authors.

Parts of speech

The concept of PoS has, of course, its own long history (see chap. 9 §4 above on Donatus, and in general Splett 2002) and is to a certain degree imposed on a language from outside. In any PoS system, there will always be cases that are hard to

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assign. The traditional system, which has been in use for Greek, Latin, and their descendent languages for more than two millennia, uses eight or nine parts of speech: noun (N), pronoun (PRON), adjective (ADJ), verb (V), adverb (ADV), conjunction (CONJ), preposition (PREP), interjection (INTER), and article (ART), the last of which is lacking in Latin. The Corpus Corporum Latin PoS tagger (TreeTagger, with language-specific data compiled by Gabriele Brandolini; http://www.cis.uni-muenchen.de/~schmid/tools/TreeTagger) uses this system and further distinguishes between some subtypes, e.g. among CONJ and PRON, verbal moods and the verb ESSE among V, and nominal cases among N. There are new approaches to defining PoS these days, designed to be applicable to all human languages. Universal PoS tags (UPOSTAG; http://universaldependencies.org/u/pos) is certainly the most successful such attempt. Table 3 compares the traditional system to UPOSTAG.

Table 3: Comparison between classical PoS and UPOSTAG.

Classical	N	*N:PR*	PRON	ADJ	V	ESSE	ADV	CONJ	PREP	*ART*	*INTER*	*NUM*	
UPOSTAG	NOUN	*PROPN*	PRON	ADJ	VERB	AUX	ADV	SCONJ CCONJ	ADP	*DET*	*INTJ*	*NUM*	*PART*

The rarer PoS italicised in table 3 (proper names, interjections, numerals) will not be used in our studies; among the rest, there is very little difference – basically only that UPOSTAG uses subordinating and coordinating CONJ as two different PoS and distinguishes particles from adverbs. Others have just received more general names (especially ‘adpositions’ instead of PREP). But, of course, the application of this general system to individual languages is still not always unambiguous. Thus, DET (‘determiners’) is wider than ART (‘articles’), and it may be debated whether any words in Latin qualify as such (e.g. *is, meus, omnis*). Another major problem is that ADJ, PRON, N, and V sometimes overlap: for instance, *omnis* can behave as ADJ, PRON, DET, or even N. Another unclear case are participles (PTC): are they ADJ or V? The automated tagging is unable to differentiate between such difficult cases: it will, for instance, always assign PRON to *omnis*,[1] and will treat lexicalised PTC as ADJ, others as V.[2]

In order to obtain a better understanding of precision and usability, the automated results of TreeTagger were evaluated by comparing them with the manual

1 This is clearly wrong in many instances. But it was not feasible to program a solution able to distinguish between cases.

2 Depending, obviously, on the lexicon used. In reality, cases such as the following should be differentiated: *docta puella* (ADJ) vs *discipulus doctus est* (V). Again, this could not be automated.

PoS tagging done by the Laboratoire d'Analyse Statistique des Langues Anciennes (LASLA)[3] for Cicero's *De officiis*. Corpus Corporum (CC) uses the Loeb edition digitised by Perseus as base text, LASLA the edition by Karl Atzert (Leipzig: Teubner, 1932). Slight differences are therefore to be expected simply because of the different base text: the Atzert edition has 386, or 1 %, more words than Loeb.[4] Table 4 presents the numbers.

Table 4: Comparison between LASLA (manually determined) and CC (automated counting) for some features in Cicero's *De officiis*. The cases were counted among N only and are given as percentages of all N.

	ADJ	ADV	CONJ	N	PREP	PRON	V	ABL/DAT	ACC	GEN	NOM
LASLA	2546	3117	4587	7530	2116	5129	8244	32.8 %	23.6 %	17.9 %	25.7 %
CC	3453	3310	3538	7545	2381	4145	8299	32.3 %	24.8 %	18.3 %	24.6 %
Difference	+36 %	+6 %	−23 %	+0 %	+13 %	−19 %	+1 %	−0.4	+1.2	+0.4	−1.2

	IND	SUB	INF	PTC	1st SG	3rd PAS
LASLA	3551	1777	1387	418	198	785
CC	3559	1726	1299	1039	207	708
Difference	+0 %	−3 %	−6 %	+148 %	+4 %	−10 %

Among the cases, the rare vocative and locative were not considered, and the ablative and dative only in their combined sum (as CC distinguishes them very poorly). The figures for CC and LASLA correspond well for some of the values (N, V, IND), but some differ conspicuously due to differences and sometimes mistakes in counting (marked in red in the table).

- There are different definitions for ADJ and PRON: CC includes e.g. *alter, nullus, alius* as ADJ (PRON in LASLA), besides some lexicalised PTC such as *praesens*. This accounts for the considerable differences. The numbers of PRON + ADJ together differ by only 1 %.
- LASLA counts the enclitics *-que* and *-ve* as separate CONJ. LASLA also counts *autem, enim*, and *vero* as CONJ:C. Subtracting these numbers (*-que*

3 The LASLA corpus data are freely available online (http://cipl93.philo.ulg.ac.be/OperaLatina/users/MainInterface.aspx) after requesting log-in details. Their manual PoS tagging is based on the Forcellini lexicon. I thank LASLA, Université de Liège, for sharing their excellent data.

4 This is also partly to do with different definitions of words. For instance, *filioque* counts as two words for LASLA, as one for CC.

108, *igitur* 103, *autem* 266, *vero* 43, *enim* 269) renders the values at least closer (–7 %).

- The difference in PREP is largely due to the word *cum*, which CC wrongly always counts as PREP. 234 of the *cum*s should be CONJ according to LASLA. This would leave a difference of 2 %. It would be very hard for software to tell the two *cum*s apart.
- Participles (PTC) used as N (such as *docti, adeptos*) are counted as N in LASLA, as V:PTC or ADJ in CC. LASLA has 621 such cases; in the list, I subtracted them from LASLA's number for N and added them to the LASLA number for V, which produced the practically identical numbers.
- The difference among the third person passives is due to the fact that CC cannot count synthetic forms such as *factum est*.

In conclusion, it seems that the results are reasonable for a fully automated counting and should be acceptable as a basis for the studies to come (although there is certainly room for improvement). As the same system was used for all texts, the results are at least consistent among themselves: the same errors will apply to all of them equally.

Corpus approach

§2 As the main basis of comparison, five large Latin ad hoc prose corpora were generated for five important time periods of Latin. The corresponding texts were loaded as TEI xml files into Corpus Corporum (CC), where automatic part of speech (PoS) tagging was performed using TreeTagger, and the resulting data downloaded again from the server as PoS-tagged TEI xml files which could be studied further with linguistic Unix tools (sed, grep, and the like). The tagging produces data of the form: <w type="PRON:DEM" lemma="hic">his</w> for each word in the text, thus assigning each word (here *his*) its lemma and a type including its PoS. If the lemma in question is not known to the database, the type will be unreliable, for instance <w type="ADJ" lemma="unknown">Chananaea</w> (type should be N:nom, not ADJ). 'Unknown' words are mostly proper names; they were removed from the samples for our studies. The entire process was based exclusively on open-source software.

Basic data about these ad hoc corpora is presented in table 5.[5] Additionally, some specific, non-scientific corpora were compiled in order to permit compari-

5 All texts are in Corpus Corporum, where further information about them, including references, can be found. These ad hoc corpora contain all prose texts from the respective corpora and time ranges (in 2018); any lines of verse in corpora 1–5 were removed. Only texts of at least 1,000 words in length were included. The author's death date or *floruit* (as available in CC) was used as an ap-

son with potentially interesting other registers. A large corpus of metrical texts (mostly hexametric), and smaller ones of the *Digesta* (see chap. 8 §3), a small collection of charters from the High Middle Ages, and the New Testament Vulgate (as a non-scientific text that was translated from the Greek) were used. It became clear above how important jurisprudence was for the development of Latin as a language of science, so the *Digesta* may reveal interesting traits. The Vulgate is included for its great importance for Christian Latin in general (see chap. 9 §2). The language of scientific poetry will be compared below, as will that of historiography, whose language may exhibit similarities with charters (both in chap. 20). The language of these additional text collections differs greatly from that of the diachronic prose texts.

Table 5: Information on the five benchmark samples and out-groups to be used below.

	Name	Source	Time range	Authors	Texts	Million words	Avg word length[6]
1	Classical Latin	Perseus collection	100 BC–AD 200	15	57	2.215	6.38
2	Late Antiquity	PL	200–450	57	430	11.102	5.63
3	Carolingian times	PL	780–900	78	331	10.447	5.75
4	Twelfth century	PL	1100–1220	162	738	26.182	5.77
5	Early modern	CroaLA (Croatian authors)	1500–1820	40	50	1.877	6.21
6	Poetry	Perseus collection and others[7]	50 BC–AD 1793[8]	162	593	3.188	5.49
7	Roman law	*Digesta*[9]	1st–6th century	38	9,139	0.840	5.72

proximation to date the texts. Obviously, undated texts were not used (CC currently has date tags for only some 85 % of its texts).

6 The average of the five prose samples is 5.95 ±0.32 letters. Mediaeval and poetic texts seem to have a shorter average word length than classical and early modern ones.

7 Comprising the texts in corpus 15 'Poetica' on CC, plus Vergil and Ovid. The longest texts are (in descending order): Michael Hospitalis, *Carmina*; *Carmina Burana*; Marcello Palingenio Stellato, *Zodiacus vitae;* Ugolino Verino, *Carlias;* Francesco Petrarca, *Africa;* Rafael Landívar, *Rusticatio mexicana*. Many of these texts were written by Italian humanists.

8 Metrical Latin poetry is very conservative, so it was decided to bring texts from different times together. We will compare the numbers to numbers obtained for Vergil and Ovid only. They are surprisingly similar.

9 The *Digesta* were collected by order of Justinian in 530–533. 9,139 is the number of excerpts, 38 is the number of authors cited in the *Florentinus* list. See chap. 8 §12 above.

Table 5: (continued)

8	Charters	Arezzo (ed. in Pasqui 1899–1937)[10]	1130–1222	n/a	115	0.081	5.81
9	Bible	Vulgate, *Novum testamentum*[11]	ca. 400	n/a	1	0.127	5.32

Parameters that may be important for scientific language were determined for the five large benchmark samples: distribution of PoS, moods, cases, suffixes, and subordinate clauses. To begin, the PoS distribution was calculated for each text within the five large diachronic samples, then values were averaged per group. This made it possible to determine standard deviations within samples, which indicate how much variation there is. The PoS distribution has changed only little over time (table 6 and fig. 31) – mostly not beyond the standard deviation range for the classical sample. The amount of verbs employed diminished somewhat through this timespan, but the amount of nominal PoS (defined as N + ADJ + PRON) rises perceptibly only in the early modern period – thus, Mediaeval Latin can hardly be said to become more 'nominal', even though the numbers of N do rise somewhat. Only the numbers of PREP rise after the first sample to a value beyond 1 stdev of the deviation within that sample. This is the only PoS consistently outside the standard deviation ranges. ADJ become much more frequent in early modern times, N become slightly more common with time, while V and PRON become less so. Averaging the PoS values for the five samples shows that the classical sample differs most strongly from the average and thus from the (mostly Christian) rest.

Table 6: Average and standard deviation for PoS over all texts in the five ad hoc prose samples as percentages of the total.Values more than 1 stdev outside the antique value are highlighted in colour:[12] red means less than the antique average minus 1 stdev, green more than the average plus 1 stdev

	100 BC–AD 200	*stdev*	200–450	*stdev*	780–900	*stdev*	1100–1220	*stdev*	1500–1820	*stdev*
ADJ	11.12	*1.54*	9.67	*3.97*	10.79	*2.42*	10.52	*2.52*	13.95	*3.00*
ADV	9.22	*1.10*	8.61	*1.98*	7.90	*1.59*	8.66	*1.96*	8.79	*1.78*

10 Digitised by the ALIM project, http://it.alim.unisi.it. The non-standardised spelling complicates the automatic tagging, and the quality of the results will be worse than usual.

11 Ed. Tweedale; see chap. 8 §2 above.

12 The values add up to only 98 %–99 % of all words because TreeTagger also tags the few abbreviations, interjections, and Roman numerals in the text.

Table 6: (continued)

CONJ	9.34	*1.56*	10.37	*1.65*	9.84	*1.98*	9.42	*1.47*	8.27	*1.88*
N	23.34	*3.84*	25.19	*4.31*	26.90	*4.02*	26.16	*4.01*	25.42	*2.98*
PREP	6.73	*1.04*	7.82	*1.48*	8.56	*1.14*	8.50	*1.27*	7.87	*1.87*
PRON	15.23	*2.97*	13.93	*2.62*	13.01	*2.28*	13.28	*2.24*	12.36	*2.44*
V	23.93	*2.12*	23.12	*2.94*	21.67	*2.43*	21.91	*2.43*	21.77	*2.30*
N + ADJ + PRON	49.69	*2.51*	48.80	*4.82*	50.71	*4.11*	49.96	*4.13*	51.73	*2.93*

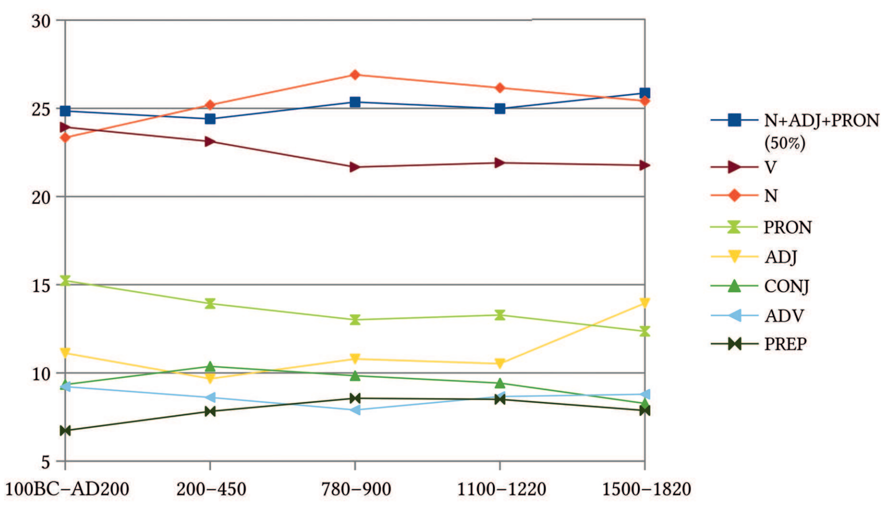

Fig. 31: PoS distribution over time. The N + ADJ + PRON value was halved to fit the scale. Values on the *y*-axis in percent.

The PoS values provide a first impression of how much (or rather, how little) variability is to be expected in Latin over the centuries. A second table (table 8 below) will compare the cases, the most important moods of the verb, and some other specific features that may be revealing for scientific language. Above (chap. 17), it was observed that scientific English tends to favour passive constructions and noun phrases. The latter correspond mostly to compounds in Greek and German (see chap. 9 §5), but in Latin they are often expressed by relative clauses. Therefore, the relative pronoun *qui* (REL) and the verb *esse*, which is often involved in such constructions, were also counted. In the wake of Greek usage, sentence-modifying or discourse particles may be another feature typical of scientific Latin:[13] *at, autem, enim, ergo, igitur, nam,* and *vero* were counted. Kroon, who studied these particles in great detail, categorises them in a table (see table 7).[14]

Table 7: Latin sentence-modifying particles, from Kroon (1995: 373).

	Presentational 'connective'	Interactional 'situating'	Interactional 'connective'
Causal/consecutive	*nam, igitur*	*enim*	*ergo*
Adversative	*autem*	*vero*	*at*

Another feature of some kinds of Latin often criticised by humanists (chap. 12 §2) is the use of suffixation, which will be discussed below as a surrogate for compounding (chap. 24 §7). In order to obtain numbers, a sample of seven especially common nominal suffixes (*-tio/-sio, -tas, -itia, -ntia, -mentum, -tor/-sor, -tudo*) and eight adjectival ones (*-alis/-aris, -bilis, -eus, -icus, -inus, -ivus, -orius, -osus*) was used. Promising suffixes for this purpose had already been selected in Roelli (2013: 334–335, based on Leumann 1944).[15] The suffixes' rôles can be briefly described as follows. For the nominal suffixes:

- *-tio/-sio:* expresses a process (e.g. *actio);*
- *-tas, -ia* (including *-itia, -ntia*), *-tudo:* express a quality (e.g. *gravitas);*
- *-mentum:* expresses a tool or the means to achieve something (e.g. *monumentum*);
- *-tor/-sor:* expresses the agent (e.g. *actor*).

  For the adjective suffixes:
- *-ivus, -orius* (added to verb roots): assert that something possesses the verbal action inherently (e.g. *activus*);
- *-bilis* (added to verb roots): expresses the possibility of undergoing the verbal action (e.g. *habitabilis*);
- *-osus, -eus* (added to nominal roots): express what something is endowed with, or what it consists of (e.g. *gratiosus*);

13 Ramshorn (1842) presents larger groups of such modifiers. Adversative particles: *sed, verum, vero, at, atqui, autem;* explanatory ones: *nam, namque, enim, etenim;* concluding ones: *itaque, igitur, ergo, eo, ideo, idcirco, propterea, (pro)inde, quare, quamobrem, quapropter*. I used only the seven most important ones, those studied by Kroon (1995).

14 Some caveats in Langslow (2000b: 559), especially for medical Latin.

15 Helander (2014: 47) studies a similar list for the adjective suffixes.

- *-icus, -alis/-aris, -inus* (added to nominal roots): express a relationship (e.g. *pluvialis*).[16]

The use of these suffixes has, on the whole, remained constant in Latin. Only very rarely did special, new constructions for some of them arise in Post-Classical Latin. For instance, the suffix *-ivus* plus objective genitive is often used in the High Middle Ages in a special syntagm (e.g. *novum testamentum est veteris impletivum*).[17] There are also suffixes derived from roots, such as *-ficus*, *-formis, -oides*, that become frequent in early modern times. It is obvious that a set of such suffixes that can enhance language systematically is very useful for scientific expression. In fact, most of these suffixes are still very common in scientific English today.

Ablativi absoluti may be another useful feature for scientists, as they make it possible to state the circumstances of the main action in a condensed way. An attempt was made to estimate their numbers automatically. Of course, counting this special feature of the Latin language automatically is not a trivial matter; in some cases it even remains unclear to Latinists whether an ablative construction is to be read as an *ablativus absolutus* or as another kind of ablative (especially an instrumental one). My tentative approach was to count all occurrences of two ablative forms with a maximum of two other words in between and no strong punctuation, where one of the two was a participle. Checking a small sample shows that most *ablativi absoluti* were indeed found, but of course there were also some false positives. A comparison with manually determined values by LASLA shows that our amounts tend to represent between 80 % and 150 % of the true value. However, as the determined numbers can, for instance, differ by a factor of ten between Pliny and Anselm of Canterbury, the numbers may still be of some relative value. The numbers are included here in the knowledge that they are not very accurate.[18] Late Antiquity has lower numbers than the rest, which have rather similar average numbers, although stdevs are large, indicating that authors differ considerably in their frequency of employing the *ablativus absolutus*.

The last feature in the table is textual entropy.[19] As in entropy defined in physics, the degree of orderliness of a text string is measured. Whereas very orderly

16 Words with these suffixes were counted using the Linux grep tool; they were required to be the correct PoS and have at least two more letters (thus excluding words such as *divus*, *vivus, binus,* etc.). For *-icus*, words in *-ficus* (compounds with *facere*) were excluded. Some false positives, such as *semivivus*, had to remain in the count and will distort the result slightly.

17 As Stotz (1996–2004: VI, §86 = vol. 2, p. 356) points out.

18 I thank Alexandra Bünzli for writing the perl script I used.

19 Proposed by Shannon (1951), then used by Evrard (1967: 81–85), this number is calculated as the negative sum $-\Sigma$ [fj × $\log_2$ (fj)] over all lemmata j, where fj is the relative frequency of lemma sequences of strings are at best very uninteresting and predictable texts, say *est est est est*, real and interesting texts are less predictable and monotonous. The entropy value is a measure that indicates the unpredictability of words in a text, the 'news value' of the next word in the sequence; it is measured in bits of information per word. Values tend to range between 7 and 11 bits. The entropy value rises slightly with more tokens; for texts with too few tokens, the value depends significantly on the text's length and therefore makes little sense. Bentz et al. (2017: 14) feel that the problems are not present above 50,000 tokens. The values below were calculated only for texts longer than 10,000 words.[20] The graphic in figure 32 makes this choice plausible.

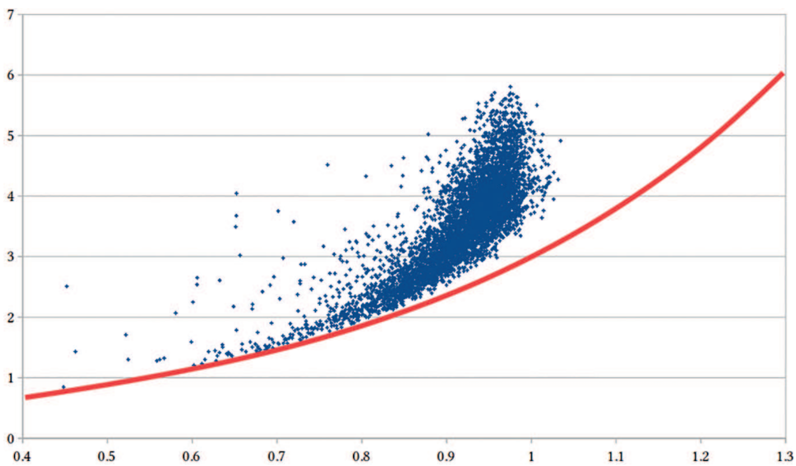

Fig. 32: Doubly logarithmic ($\log_{10}$) plot of entropy values for all texts in PL: the *x*-axis shows the entropy value, the *y*-axis the number of tokens (words). The red curve shows the maximum possible entropy value ($\log_2$ of the number of tokens), representing the case that each token is used exactly once. Above *y*-value 4 (10,000 tokens), the real values no longer seem to follow the maximum possible value closely.

The first thing that hits the eye in table 8 is that the standard deviations for all moods and cases are relatively high: different authors differ strongly, even within the same period. Nonetheless, there are some parameters that deviate on average more than 1 stdev from the classical value (again, highlighted in colour). The

j. The same formula is used to calculate entropy in information theory, hence the name. More precisely, this is uni-gram entropy, as defined in Bentz et al. (2017: 5, formula 3).

20 For the five corpora in ascending chronological order, this means 40, 242, 161, 375, and 18 texts respectively.

amounts of IND rise significantly in the Middle Ages and drop even more afterwards, when humanists overcompensate in employing this un-classical usage. SUB exhibit the inverse behaviour. INF drop in the Middle Ages while PTC rise. The former change is very conspicuous, such that lower numbers of infinitives might be a typical characteristic of Mediaeval Latin. As ACC numbers also drop somewhat, this may be connected with the rarer use of the *accusativus cum infinitivo*. Interestingly, the humanists have somewhat higher numbers of INF again, but use PTC even more than Antiquity. This may be an attempt to imitate Greek, a language very fond of participle constructions. In the Middle Ages, the high PTC numbers may point to influence from biblical Latin (although the value for our NT Vulgate sample is only slightly higher than the benchmarks).

Table 8: Some more specific, potential characteristics for scientific language. The verbal forms are given as percentages of all V, the nominal ones as percentages of all N. For details, see the main text.

	100 BC–AD 200	*stdev*	200–450	*stdev*	780–900	*stdev*	1100–1220	*stdev*	1500–1820	*stdev*
IND (% of V)	45.60	*4.70*	50.40	*7.39*	47.49	*8.60*	50.88	*7.86*	42.64	*7.30*
SUB (% of V)	16.71	*3.26*	14.90	*3.71*	14.40	*5.47*	13.58	*5.82*	14.87	*4.52*
INF (% of V)	15.07	*2.92*	11.50	*3.96*	11.34	*3.29*	11.04	*3.61*	12.71	*3.51*
PTC (% of V)	17.52	*5.24*	18.03	*5.31*	21.25	*7.04*	19.38	*6.22*	23.50	*5.42*
NOM (% of N)	26.52	*3.57*	30.02	*6.06*	27.12	*4.66*	28.36	*4.66*	25.49	*4.55*
GEN (% of N)	12.46	*1.97*	14.93	*2.97*	16.78	*3.06*	16.32	*3.06*	15.74	*2.76*
ACC (% of N)	27.42	*4.00*	26.58	*3.68*	24.10	*3.80*	24.56	*3.55*	26.28	*3.65*
ABL/DAT (% of N)	33.60	*3.43*	28.47	*4.68*	32.00	*4.70*	30.76	*4.71*	32.48	*4.5*
ESSE (%)	3.80	*0.99*	3.82	*1.26*	3.15	*1.15*	3.29	*1.31*	2.63	*0.95*
REL (%)	3.98	*0.75*	3.68	*0.79*	3.38	*0.73*	3.49	*0.71*	2.96	*0.83*
CONJ:S (%)	2.86	*0.69*	3.20	*0.92*	2.91	*0.86*	2.88	*0.79*	2.29	*0.61*
1st SG (% of V)	6.79	*4.29*	4.26	*3.42*	3.10	*2.77*	3.38	*2.53*	5.43	*5.00*
3rd PAS (% of V)	6.38	*2.43*	8.05	*2.67*	8.41	*3.16*	9.01	*3.80*	6.09	*2.68*
ADJ-SUF (%)	1.29	*0.40*	1.14	*0.47*	1.57	*0.73*	1.51	*0.57*	1.52	*0.69*
N-SUF (%)	3.80	*1.02*	4.19	*1.25*	4.86	*1.16*	5.03	*1.42*	4.02	*1.48*
Modifiers (%)	1.42	*0.62*	1.78	*0.75*	1.28	*0.56*	1.40	*0.59*	1.02	*0.49*
ABL ABS per 1,000 words	3.45	*2.48*	2.56	*1.80*	3.77	*2.68*	3.17	*2.30*	3.95	*1.82*
Entropy	9.36	*0.50*	8.83	*0.53*	9.11	*0.42*	9.16	*0.47*	9.27	*0.61*

The use of cases remains relatively stable for NOM and ACC, except that the sample from Late Antiquity exhibits a rather high percentage of NOM and a correspondingly low number of ABL/DAT, possibly because these cases were becoming rarer in the still-spoken language. The number rises again from Carolingian times onward (when grammar was learned in school). Most interesting for scientific language may be GEN, which is the only case that becomes more than 1 stdev more common as time passes, and even remains so in the humanist sample. This may be one of the reasons why Mediaeval Latin gives the impression of being more 'nominal',[21] as 'nominal' GEN constructions contrast with 'verbal' ACC constructions. Unexpectedly, both ESSE and the REL pronoun become rarer as time passes, although strongly so only in the humanist sample. Constructions with relative clauses and a high concentration of the copula will have been perceived as 'scholastic' and worth avoiding, although it can now be seen that they were even more common in classical times. The third person passive (singular and plural) is somewhat more common in the Middle Ages than before or after, but it is the first person singular that surprises by being a lot less common in the Middle Ages. Interestingly, the numbers of the third person passive are highest for the twelfth-century sample, at the beginning of scholastic writing. Nominal suffixes are clearly another feature that was perceived as 'scholastic' and avoided in the humanist sample, though adjective suffixes apparently were not.

More detailed data about these suffixes are shown in table 9 and figure 33. Because their occurrences are usually low in number, and chance fluctuations are thus to be expected, averages across all texts were used (thus, no longer counting per text then averaging the numbers obtained for each text in one corpus), except for the first corpus (Antiquity) in order to still have a stdev value. The first and third rows in table 9 thus reflect the difference one will generally have to expect between these two ways of counting. It is mostly small (very small for the PoS in table 6 above, numbers not printed); only *-bilis, -ivus, -osus; -itia, -ntia* exhibit a difference of more than 10 %, indicating that their frequencies were especially variable among antique authors and texts. Standard deviations are in general high; only *-alis* and *-tio* consistently reach values more than 1 stdev higher than in the classical samples in the Middle Ages and early modern times. But, presumably due to criticism by humanists, some frequencies drop significantly in early modern times compared to the Middle Ages, especially for *-tas, -ntia, -bilis* – most abruptly for the first.[22] Some others, which were apparently not consciously asso-

21 See chap. 11 §2 above: Stotz on scholasticism's 'ausgesprochenen Nominalstil' ('pronounced nominal style').

22 This suffix was especially targeted by the humanists, e.g. Lorenzo Valla, quoted in chap. 12 §2 above.

ciated with 'scholasticism', such as *-tio, -alis*, keep rising through the entire sample period; a few (*-eus, -ivus*) rise decidedly in early modern times; and some remain quite constant (*-mentum, -osus, -tudo, -itia*).[23]

Table 9: Occurrences of suffixes in ‰ of words. The first row was measured per text and then averaged; the second row contains the stdev over all texts in the same corpus. All further rows are simple averages over all texts in the respective corpus. Thus, the second 100 BC–AD 200 row is the one that should be compared to the numbers from the other corpora.

	-alis/-aris	*-bilis*	*-eus*	*-icus*	*-inus*	*-ivus*	*-orius*	*-osus*	*-itia*	*-mentum*	*-ntia*	*-tas*	*-tio*	*-tor*	*-tudo*
100 BC–AD 200	2.24	1.29	0.75	3.30	1.12	0.32	0.26	1.89	1.76	1.88	4.42	10.73	9.69	4.08	2.26
stdev	*0.81*	*0.73*	*0.81*	*2.05*	*0.71*	*0.23*	*0.24*	*1.04*	*1.30*	*1.00*	*2.08*	*3.76*	*4.97*	*2.42*	*1.62*
100 BC–AD 200	2.24	1.08	0.81	3.08	1.10	0.28	0.28	1.61	1.41	1.85	4.01	10.10	10.20	4.24	2.26
200–450	2.94	1.69	0.93	1.99	1.30	0.19	0.09	1.10	1.99	2.03	4.97	11.78	12.76	3.66	1.90
780–900	3.61	2.08	1.08	2.93	1.98	0.44	0.33	1.06	1.91	2.07	5.51	12.78	16.08	4.66	2.12
1100–1220	4.08	2.09	1.05	3.09	1.58	0.37	0.33	1.26	2.06	2.01	6.05	13.40	17.18	3.86	2.37
1500–1820	4.30	1.02	1.47	2.93	1.25	0.70	0.24	1.01	1.85	2.14	4.65	9.10	16.64	3.64	1.82
avg	**3.44**	**1.59**	**1.07**	**2.81**	**1.44**	**0.40**	**0.25**	**1.21**	**1.85**	**2.02**	**5.04**	**11.44**	**14.56**	**4.01**	**2.09**
stdev	*0.85*	*0.52*	*0.25*	*0.46*	*0.35*	*0.19*	*0.10*	*0.24*	*0.25*	*0.11*	*0.78*	*1.80*	*3.00*	*0.43*	*0.23*

Finally, a closer look is taken at subordination, which seems to be of special importance for the well-structured, syntactic connection of scientific thoughts. Total numbers are counted in table 10 below.[24] The general numbers above (table 6) have shown that numbers of subordinating CONJ remain quite constant, before dropping significantly in the early modern sample. A selection of eight CONJ:S

23 These results are comparable to those in Roelli (2013), which were acquired from a much smaller sample.

24 The common ones in the benchmark samples are *antequam, cum/quum, donec, dum, dummodo, etiamsi, etsi, igitur, ne, neve, ni, nisi, nonnisi, posteaquam, postquam, priusquam, prout, quam, quamquam, quamvis, quando, quandoquidem, quanquam, quasi, quia, quo, quod, quominus, quoniam, si, sin, siquidem, tametsi, tamquam, tanquam, ut.*

and two conspicuous PREP, sometimes in semantic groups, was counted to this end (*qui* was already included in table 8 above as REL).

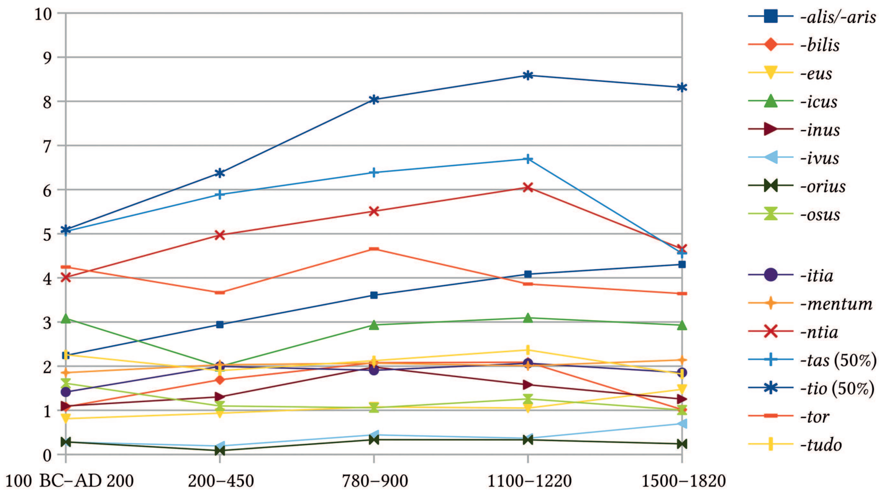

Fig. 33: Suffixes in the five samples in ‰. The values of the two most common nominal suffixes, *-tas* and *-tio*, have been halved to fit the scale.

Table 10: Numbers for some subordinating CONJ in ‰. For the differences between the first and third rows, see the comments on table 9.

Main function	Conditional	Final	Causal	Exceptive	Comparative	Temporal	Several	Concessive	Several[25]	PREP of conformity	
	si(-quidem)	*ut* (and *ne*)	*quia*	*nisi*	*quasi, tamquam*	*donec, dum*	*quoniam*	*quamquam, quamvis, licet*	*cum* (CONJ)	*quoad*[26]	*secundum*
100 BC–AD 200	7.33	13.26	1.00	1.56	1.55	0.69	0.79	0.84	6.31	0.075	0.14
stdev	*3.00*	*4.27*	*0.83*	*0.63*	*1.39*	*0.58*	*0.63*	*0.47*	*2.20*	*0.101*	*0.20*
100 BC–AD 200	7.26	13.88	1.08	1.63	1.29	0.64	0.67	0.81	6.94	0.098	0.16

25 Corpus Corporum cannot distinguish between the two *cums*. Roelli (2013) determined that an average 74 % of occurrences are of the conjunction; the total number has been multiplied by this value. The accuracy of these numbers is, therefore, worse than that of the others, as the ratio is likely to change depending on the author.
26 Both *quoad* and *quo ad* were counted, the latter orthography being rather rarer in our texts.

Table 10: (continued)

200–450	6.26	12.03	5.32	1.90	1.29	0.81	1.21	0.56	5.03	0.004	1.19
780–900	4.78	11.24	6.38	1.39	1.16	1.17	1.05	0.50	4.49	0.005	1.33
1100–1220	4.97	10.46	5.69	1.49	1.51	1.24	0.95	0.51	5.01	0.020	1.26
1500–1820	2.99	11.20	2.12	0.63	0.95	0.94	0.35	0.41	4.98	0.113	0.51
avg	**5.23**	**11.76**	**4.12**	**1.41**	**1.24**	**0.96**	**0.85**	**0.56**	**5.29**	**0.048**	**0.89**
stdev	*1.65*	*1.31*	*2.36*	*0.48*	*0.21*	*0.25*	*0.34*	*0.15*	*0.95*	*0.053*	*0.52*

As expected, many of these numbers are reasonably stable through time (e.g. for *quasi*, *tamquam* and *cum;* slightly falling for *ut*), but often the stdev is high. Some seem to be especially 'mediaeval': *quia*, *quoniam*, and *secundum*, although the values from the early modern corpus are still a lot higher than the classical ones (except *quoniam*); *quoad* behaves in exactly the opposite manner, although it is much rarer. Indeed, *quia* and *quoniam* are used much more profusely in the Middle Ages in situations where Antiquity would prefer other constructions, especially the AcI (it was found above that the Middle Ages have conspicuously lower numbers for INF).[27] The Croatian early modern authors seem to avoid hypotaxis quite generally, possibly because it was felt to be a trait of mediaeval, 'barbarous' Latin. Thus, their numbers for relative sentences and *si* and *nisi* are much lower than the mediaeval *and* the antique values, which are similar to each other.

These numbers obtained from the five large corpora representing five important periods will now serve as benchmark values to compare against the scientific samples.

General scientific corpus

§3 The table below (§4) summarises important data about the forty texts chosen for this general, diachronic scientific corpus and provides some initial linguistic information about the texts.[28] The texts cover rather different topics and may thus

27 See Stotz (1996–2004: IX, §106 = vol. 4, pp. 397–398 on *quia*; IX, §107 = vol. 4, pp. 398–399 on *quoniam*). His observation (p. 398) that *quoniam* remains significantly rarer than *quod* and *quia* is confirmed by our numbers.

28 Details about the editions used can be found in the bibliography. All texts are in Corpus Corporum.

serve to illustrate general trend developments. They were chosen as relatively original treatments of a scientific subject, excluding mere schoolbooks, technical manuals, translations, and texts written in verse. Some scientific texts translated from Greek are included in the study as out-groups: four texts translated under different circumstances and at different times (listed at the end of the table). After this table listing the texts used in the sample, a table with the PoS distribution and another one with the other parameters discussed above for the benchmark samples follow. Average figures of the more homogeneous samples studied in the next chapter are also displayed in the tables: text samples from arithmetic, historiography, and didactic/scientific poetry.

In order to gain an insight into the innovated technical vocabulary, words not occurring in Antiquity were counted in the last 5,000 words (thus avoiding the special language used in prefaces) of each work in this corpus.[29] In order to find them, an 'Antiquity word-list' was first generated from texts by authors between 100 BC and AD 200 from corpora 4 and 5 in CC (171 texts, yielding some 257,333 words), which was subtracted from the word-lists of later texts in the sample.[30] The resulting word-lists of post-antique lemmata for each author are printed in appendix 1 at the end of this book. The 31 scientific texts after AD 200 in total contain 917 [3,032] lemmata [occurrences] not extant in the sample for before AD 200. Among these were 294 [1145] ADJ, 20 [37] ADV, 465 [1,544] N, and 138 [306] V. Thus, at least these post-antique words do show a decidedly nominal character. The numbers vary strongly depending on the scientific field. Logical or philosophical texts (Boethius, Anselm, Spinoza) only rarely use new words, unless they belong to university scholasticism (Suárez). Indeed, the author who uses by far the most such words is the twentieth-century Jesuit Boyer. Among the humanist authors, some exhibit lower numbers (Cardano, Vesalius, Descartes, Newton, Kretschmann), but even avowed classicists such as Vesalius cannot help using some late words in a field like medicine. The comparison with the out-groups shows that, interestingly, the Vulgate uses quite precisely the same number of new words as the average of the scientific texts.[31] Since the numbers depend

29 A similar experiment with only classical authors (Cicero, Caesar, Cornelius Nepos, Pliny the Younger, Quintilian, *Ad Herennium*, Ps-Caesar, Livy, and Sallust, in total some 54 texts – compare Krebs, who recommends the 'pure' style of the later authors Pliny the Younger and Quintilian) produced too many words, many of which are seemingly completely normal Latin that just happened not to be present in the relatively small sample of 'authoritative' texts. They are not included.

30 Some manual clean-up and lemmatising of words unknown to Corpus Corporum's lemmatiser had to be done.

31 This procedure was also applied to the Vulgate text: 41 lemmata [101 instances] were found, also listed in appendix 1.

strongly on the scientific field and possibly also on the part of the work from which the 5,000 words were taken, they are not used as a parameter for the plots below.[32]

The list in the appendix shows that Latin scientific language created nouns, adjectives, and verbs in large numbers, but there are very few new uninflected words (*aptota*).[33] The only one discussed in this book is the scholastic pseudo-article *ly* (see chap. 24 §6 below). It remained marginal and was no longer employed in early modern times. Nevertheless, it will become clear that some *aptota* are much more common in scientific writing, especially PREP and in some authors ADV. Some cases are conspicuous, for instance *secundum*. A look at the entries in Schütz yields, besides *ly*, only *aptota* that are adverbs derived from adjectives, in *-e*, *-ter*, and some less regular ones in *-im* (*capitulatim, coniunctim, copulatim, disiunctim, divisim, subalternatim, summatim*). It may be a generalisable finding that technical languages create new vocabulary nearly exclusively among the open (inflectable) word classes, hardly ever among the structure words of a language. The latter would constitute a much deeper intervention in language, on the way toward language engineering.

§4 There follow the tables with information about the texts used and the figures obtained for them (tables 8–10). The texts of translations from Greek in the second part of the table are included for comparison. The first column indicates the text and edition used for the calculations. Often these are not the latest or best critical editions but those that were available in digital form.[34] It is not to be expected that the differences would result in greatly differing numerical values. The scientific field with which the text is concerned and the text's style are also briefly described in the table. For deeper information, the reader is referred back to part 2, where the works were discussed. The brief assessment of the type of language used is, of course, rather subjective. It is meant merely as an indication what the Latin these texts use 'feels' like to the reader.

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32 If the entire process of finding post-antique lemmata could be automated, average numbers for any sample of 5,000 words could be calculated. But at present, listing these words is still partly manual work.

33 On *aptota* in Indo-European, see Dunkel (2014).

34 Restrictive copyright laws and editorial policies make it impossible to work with the latest editions in many cases. Of course, the best editions available were used in part 2 above.

Table 11: Authors and text used in this corpus (part 1), and out-groups of some translations from Greek (part 2).

Author and work[35]	Life dates	Main scientific topic, in modern terminology	No. of words,[36] average word length	Post-classical words, types/ tokens	Brief description of style	Knew Greek?	Quotes authorities in significant number?	Diagrams, formulas, graphics?	See above
Varro, *De lingua latina*, ed. Müller (1833)	116–27 BC	Latin linguistics	40 5.34	0 0	unrhetorical with pre-classical features	Y	Y	N	3 §5
Cicero, *De natura deorum*, ed. Plasberg (1917)	106–43 BC	religious studies	36 5.69	0 0	very rhetorical	Y	Y	N	3 §7
Vitruvius, *De architectura*, ed. Krohn (1912)	ca. 75–ca. 15 BC	engineering	58 6.24	0 0	technical	Y	N	G (lost)	3 §7
Seneca, *De rerum natura*, ed. Corcoran (1971–1972)	ca. 4 BC–AD 65	meteorology, geology	48 5.58	0 0	matter of fact but still rhetorical	Y	Y	N	3 §8
Pliny, *Naturalis historia*, ed. Ianus (1854–1855)	23–79	compendium of natural philosophy	399 6.04	0 0	careless	Y	Y	N	3 §10
Apuleius, *De deo Socratis*, ed. Beaujeu (1973)	ca. 125–ca. 180	demonology	9 6.11	0 0	imitating Aristotelian Greek	Y	Y	N	3 §11
Gaius, *Institutiones*, ed. Seckel & Kuebler (1908)	fl. 160	jurisprudence	43 5.61	0 0	juridic, introductory	Y?	Y	N	3 §12
Pauli sententiae, ed. Baviera (1968)	2nd/3rd century	jurisprudence	21 6.01	0 0	juridic, aphoristic	Y?	N	N	3 §12
Tertullian, *De anima*, ed. Reifferscheid (1890)	ca. 160–ca. 225	theology	24 7.66	81 110	bombastic	Y	Y	N	4 §2

35 Red indicates less than the average minus 1 stdev, green more than the average plus 1 stdev.

36 The number of words was counted in thousands. The shortest texts are around 8,000 words; most are much longer.

Table 11: (continued)

Author and work[35]	Life dates	Main scientific topic, in modern terminology	No. of words,[36] average word length	Post-classical words, types/ tokens	Brief description of style	Knew Greek?	Quotes authorities in significant number?	Diagrams, formulas, graphics?	See above
Victorinus, *De definitione* PL 64 (1891)	ca. 285–ca. 365	logic	8 5.68	5 134	imitating Greek	Y	Y	N	4 §3
Augustine, *De doctrina christiana* PL 34 (1865)	354–430	theology, semantics	43 5.74	39 73	rhetorical	some	Y	N	4 §2
Donatus, *Ars maior*, ed. Holtz (1981)	ca. 350	grammar	10 5.86	71 163	school Latin	Y?	Y	N	4 §3
Boethius, *In Isagogen 1*, ed. Brandt (1906)	ca. 480–524	logic commentary	26 5.74	12 69	quite Aristotelian, dialogue	Y	Y	N	4 §7
Boethius, *In Isagogen 2*, ed. Brandt (1906)	ca. 480–524	logic commentary	37 5.86	13 62	Aristotelian-scholastic	Y	Y	N	4 §7
Isidore, *Etymologiae*, ed. Lindsay (1911)	ca. 560–636	compendium, mostly of natural philosophy	169 5.93	52 96	compendium style	N	Y	G	4 §8
Bede, *De ratione temporum* PL 90 (1904)	672/673–735	chronology, calendar calculation	52 5.91	62 160	technical-didactic	N	Y	N	4 §10
Rabanus, *De universo* PL 111 (1864)	ca. 780–856	compendium of natural philosophy	247 5.87	71 125	compendium style	N	Y	N	4 §11
Eriugena, *Periphyseon* PL 122 (1865)	ca. 810–ca. 877	mystical theology	214 5.99	63 132	dialogue, imitating Ps-Dionysius' Greek	Y	Y	G	4 §11
Anselm, *Cur Deus homo* PL 158 (1863)	1033–1109	Christological theology	29 5.16	8 17	early scholastic dialogue	N	N	N	5 §2

Table 11: (continued)

Author and work[35]	Life dates	Main scientific topic, in modern terminology	No. of words,[36] average word length	Post-classical words, types/ tokens	Brief description of style	Knew Greek?	Quotes authorities in significant number?	Diagrams, formulas, graphics?	See above
Abelard, *De dialectica*, ed. De Rijk (1970)	1079–1142	logic	171 5.98	29 108	early scholastic	N	N	N	5 §3
Guilelmus de Conchis, *De philosophia*, ed. Maurach (1970)	ca. 1080–ca. 1154	natural science	22 5.74	39 88	early scholastic compendium style	N	Y	G	5 §3
Hugh of St Victor, *Didascalicon* PL 176 (1880)	ca. 1100–1141	theory of learning	39 6.07	32 101	early scholastic	some	Y	N	5 §1
Albertus, *De homine*, ed. Anzulewicz (2008)	1193–1280	anthropology	311 5.95	46 83	scholastic	N	Y	N	6 §2
Aquinas, *Summa contra gentiles*, Leonina edition (1961)	1224/ 1225–1274	theology	285 5.77	43 120	scholastic	N	Y	N	6 §1
Roger Bacon, *Opus maius*, ed. Bridges (1897)	ca. 1214–1294	scientific methodology	237 5.70	38 75	less scholastic	some	Y	N	6 §3
Lullus, *Ars generalis ultima*, ed. Madre (1986)	ca. 1232–ca. 1315	combinatorics	158 5.53	50 106	non-university, idiosyncratic	N	N	F G	7 §5
Duns Scotus, *In Metaphysicam* (books I, II, VI, VIII, IX), ed. Vives (1891–1895)	1266–1308	metaphysics	214 5.69	53 125	scholastic, very technical	N	N	N	6 §5
Ockham, *Summa logicae* (I, II, III.2), ed. Boehner (1974)	ca. 1287–1347	logic	99 5.76	37 121	scholastic, very technical	N	N	N	6 §5

Table 11: (continued)

Author and work[35]	Life dates	Main scientific topic, in modern terminology	No. of words,[36] average word length	Post-classical words, types/ tokens	Brief description of style	Knew Greek?	Quotes authorities in significant number?	Diagrams, formulas, graphics?	See above
Copernicus, *De revolutione* I (Norimbergae, 1543)	1473–1543	astronomy	12 6.09	18 77	humanist mathematical	Y	N	D G	8 §4
Cardanus, *De subtilitate* (Lugduni, 1663)	1501–1576	technological compendium	262 6.20	14 17	humanist encyclopaedic	Y	N	G	7 §4
Vesalius, *De corpore humano* I (Basileae, 1543)	1514–1564	anatomy	103 6.20	26 49	classicist	Y	N	G	8 §4
Suárez, *Disputationes metaphysicae* (Paris, 1866)	1548–1617	metaphysics	1,385 5.76	45 137	neo-scholastic	Y	Y	N	6 §7
Galileo, *Sidereus nuntius* (Venetiis, 1610)	1564–1642	astronomy	10 6.22	30 97	astronomical-technical	N?	N	D	8 §4
Vossius, *Ars historica* (Lugduni Batavorum, 1653)	1577–1649	historical method	49 6.08	7 10	academic	Y	Y	N	3 §5
Descartes, *Principia philosophiae* (Amstelodami, 1692)	1596–1650	methodology, foundation of natural science	69 5.64	32 56	academic	Y	N	G	8 §4
Spinoza, *Ethica more geometrico* ([Amsterdam], 1677)	1632–1677	deductive ethics	78 5.69	14 33	philosophical-technical	Y	N	N	8 §4
Kircher, *China illustrata* (Amsterdam, 1667)	1602–1680	ethnography, history of religion	11 6.43	62 88	Baroque science, academic	Y	Y	G	8 §4
Newton, *Principia mathematica* (Londini, 1686)	1642–1726	astronomy/physics	118 5.84	35 135	mathematical-technical	Y	N	F D	8 §4

Table 11: (continued)

Author and work[35]	Life dates	Main scientific topic, in modern terminology	No. of words,[36] average word length	Post-classical words, types/ tokens	Brief description of style	Knew Greek?	Quotes authorities in significant number?	Diagrams, formulas, graphics?	See above
Kretschmann, *De latinitate Apulei* (Königsberg, 1865)	1844–after 1910	Latin philology	10 6.72	21 28	humanist scholarly	Y	Y	N	8 §5
Boyer, *Cursus philosophiae* (Paris, 1952)	1884–1980	natural science, ethics	259 6.20[37]	114 253[38]	Jesuit neo-scholastic	Y	Y	F	10 §5
Boethius, *Aristotelis De interpretatione* PL 64 (1891)	ca. 480–524	epistemology	108 5.70	13 39	imitating Aristotle	Y			4 §7
Gerard of Cremona, *Liber de causis*, ed. Zimmermann (2001)	ca. 1114–1187	metaphysics	7 5.46	26 71	mostly translated from Proclus, through Arabic	Y			5 §5
Iohannes Argyropoulos, *Aristotelis Physica*, ed. Bekker (1843)	ca. 1415–1487	physics	57 5.15	15 29	humanist, translator's first language was Greek	Y			7 §2
Marsilio Ficino, *Iamblichi De mysteriis* (Venetiis, 1497)	1433–1499	mystical theology	27 6.46	35 71	humanist, translator's first language was Latin	Y			7 §4

37 Average word length of these texts: 5.84 ±0.29, somewhat shorter than the benchmark: 5.95 ±0.32.
38 Averages: 39.4 ±24.5, 95.3 ±50.3.

Table 12: PoS values for the scientific texts in comparison to the benchmark general texts, as percentages. The colours green and red are used to show differences from the average of the five prose benchmark texts that exceed 1 stdev.[39] Values more than 3 times the stdev from the average are underlined. The average and stdev values from the arithmetic corpus (studied in the next chapter) are included for comparison.

PoS data	ADJ	ADV	CONJ	N	PREP	PRON	V
Varro	10.85	9.08	8.97	24.58	10.56	14.46	21.50
Cicero	9.91	9.97	10.24	24.36	6.50	15.76	23.25
Vitruvius	11.58	8.45	8.23	30.58	10.53	8.72	21.91
Seneca	11.23	10.42	9.34	22.56	7.20	13.98	25.27
Pliny	14.40	7.14	8.10	32.75	8.79	8.78	20.03
Apuleius	13.39	7.90	11.55	26.32	5.50	12.70	22.64
Gaius	8.49	9.73	11.02	24.79	8.16	13.96	23.85
Pauli sententiae	9.10	6.97	9.32	29.35	8.70	10.74	25.82
Tertullian	10.24	11.01	13.34	26.63	8.20	10.98	19.59
Victorinus	9.55	8.70	10.08	22.23	7.70	15.38	26.35
Augustine	9.38	10.47	11.40	21.25	7.35	15.30	24.85
Donatus	17.73	6.52	13.66	24.07	8.95	9.60	19.48
Boethius 1	11.04	10.22	12.34	22.29	7.52	14.58	22.01
Boethius 2	12.06	11.42	11.10	21.17	7.81	14.30	22.14
Isidore	10.67	7.81	9.70	29.39	8.87	10.94	22.61
Bede	16.56	7.53	7.41	31.16	8.50	9.66	19.19
Rabanus	10.41	7.47	8.90	32.59	9.04	10.78	20.82
Eriugena	11.67	9.98	10.90	23.73	8.85	13.71	21.16
Anselm	10.90	12.36	12.88	16.13	7.37	18.44	21.92
Abelard	10.70	13.07	10.33	19.52	9.15	14.05	23.17
Guil. de Conchis	11.11	10.26	10.44	23.34	10.55	11.49	22.82
Hugh	12.36	9.57	9.44	26.49	8.13	11.06	22.95
Albertus	11.39	10.99	10.03	22.27	11.80	12.76	20.77
Aquinas	10.38	10.92	9.07	22.17	10.52	14.58	22.36
Roger Bacon	12.41	8.77	12.44	24.88	10.57	10.84	20.10

39 The samples are treated as a single text. This explains the (small) differences from the numbers in table 6 above.

Table 12: (continued)

PoS data	ADJ	ADV	CONJ	N	PREP	PRON	V
Lullus	11.66	8.18	10.28	22.85	12.82	12.11	22.09
Duns Scotus	13.23	12.47	9.60	19.39	11.87	13.28	20.16
Ockham	12.63	11.17	10.49	18.13	9.21	15.10	23.26
Copernicus	14.18	9.40	7.24	23.68	11.25	12.92	21.33
Cardanus	13.00	11.59	10.05	26.03	8.54	9.65	21.14
Vesalius	16.31	11.81	7.69	28.15	7.15	10.71	18.18
Suárez	11.42	11.46	12.23	20.53	10.55	12.29	21.52
Galileo	21.07	11.11	6.88	22.24	9.79	9.71	19.20
Vossius	11.62	10.68	10.74	25.96	8.23	10.73	22.03
Descartes	11.38	11.62	9.76	20.65	10.39	15.59	20.61
Spinoza	9.38	8.89	10.10	22.26	9.19	16.95	23.22
Kircher	14.67	8.34	4.50	27.52	9.43	13.75	21.80
Newton	13.60	7.02	7.09	27.75	14.14	10.52	19.88
Kretschmann	19.01	10.15	8.46	25.73	5.72	9.95	20.98
Boyer	13.77	9.09	9.25	24.15	9.97	11.06	22.72
avg	**12.36**	**9.74**	**9.86**	**24.49**	**9.13**	**12.55**	**21.87**
stdev	*2.73*	*1.69*	*1.89*	*3.81*	*1.82*	*2.38*	*1.83*
De interpretatione	14.25	15.30	12.42	18.19	6.45	16.69	16.70
Liber de causis	12.72	9.98	14.07	22.61	11.05	16.39	13.18
Argyropoulos	10.75	14.77	14.66	16.50	8.29	18.98	16.04
Ficinus	14.85	12.05	6.87	25.40	9.62	12.55	18.66
avg	**13.14**	**13.02**	**12.01**	**20.68**	**8.85**	**16.15**	**16.15**
stdev	*1.83*	*2.48*	*3.55*	*4.07*	*1.96*	*2.67*	*2.27*

Table 12: (continued)

PoS data	ADJ	ADV	CONJ	N	PREP	PRON	V
Arithmetic (chap. 20)	**18.60**	**8.86**	**10.82**	**18.18**	**11.86**	**10.98**	**20.69**
stdev	*2.83*	*1.69*	*1.59*	*3.32*	*2.17*	*1.39*	*2.53*
100 BC–AD 200	10.40	9.59	9.43	23.65	7.09	15.65	24.19
200–450	8.67	9.13	10.52	24.90	7.98	14.87	23.93
780–900	10.10	8.21	10.20	27.03	8.81	13.50	22.15
1100–1220	10.09	8.67	9.79	26.73	8.82	13.76	22.14
1500–1820	11.05	9.17	9.73	26.11	8.82	12.87	22.25
avg	**10.06**	**8.95**	**9.93**	**25.69**	**8.30**	**14.13**	**22.93**
stdev	*0.87*	*0.53*	*0.43*	*1.40*	*0.77*	*1.12*	*1.03*
Digesta	8.45	8.03	11.08	25.52	7.79	12.30	26.84
Vulgate	5.81	8.55	12.26	24.83	9.36	17.73	21.46
Charter corpus	11.90	7.86	11.61	26.24	11.10	12.90	18.38
Poetry corpus	15.52	7.23	7.28	30.54	4.38	10.49	24.57
Vergil/Ovid	13.90	6.74	6.88	31.14	4.29	10.42	26.62
Scientific poetry (chap. 20)	14.97	8.51	8.05	29.67	5.28	9.19	24.33

Table 13: The first four values, the 1st person singular, and the 3rd person passive are measured as percentages of all V per text, the cases as percentages of N (the rare cases VOC and LOC are not included). All other values are in simple percentages, except ABL ABS (which is given in occurrences per 1,000 words) and entropy (in bits per word). Colours are used as in table 12.

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Varro	51.57	13.74	12.61	16.60	30.42	12.55	26.87	30.16	3.93	6.58	3.45	0.35	5.63	10.36	0.93	2.10	0.84	1.36	8.86
Cicero	44.55	18.65	17.32	15.83	23.94	17.10	28.23	30.73	4.73	4.81	3.30	0.58	4.88	10.04	1.27	2.77	2.78	2.34	9.09
Vitruvius	45.11	15.97	9.65	24.54	20.23	19.42	28.67	31.68	4.14	3.31	2.06	0.23	2.06	17.92	1.46	4.95	2.15	4.06	9.35
Seneca	54.65	13.65	12.73	16.89	25.16	14.56	34.46	25.83	4.30	3.72	2.56	0.81	3.05	8.97	0.89	1.91	1.48	3.82	9.41
Pliny	47.47	9.75	11.77	27.87	19.07	17.43	24.51	38.99	2.12	2.49	1.71	0.31	1.23	13.56	1.93	2.26	0.84	7.81	10.38
Apuleius	39.24	14.49	20.97	19.92	19.44	21.18	30.23	29.14	4.75	3.74	1.94	0.51	0.55	10.06	1.76	6.35	1.01	3.60	9.22
Gaius	47.07	18.51	16.27	14.99	24.38	15.44	26.55	33.63	4.87	4.03	3.84	0.86	1.07	13.95	0.89	5.34	1.70	2.85	9.14
Pauli sententiae	46.31	13.80	14.28	20.26	23.40	17.49	27.19	31.92	2.73	3.90	3.10	0.66	1.36	17.51	1.31	5.65	0.85	4.52	8.57
Tertullian	50.19	14.35	12.76	18.29	24.32	21.97	26.41	27.29	2.65	3.16	4.00	0.72	3.67	13.11	2.18	4.27	1.72	2.05	9.34
Victorinus	51.82	17.35	11.81	15.11	37.04	13.25	23.34	26.38	7.90	4.74	3.61	0.61	2.44	11.28	1.33	8.21	1.82	4.39	7.99
Augustine	48.15	15.44	12.18	16.18	24.40	18.09	27.38	30.14	4.24	4.77	3.64	0.89	2.72	11.23	1.22	4.50	2.13	2.78	9.09
Donatus	66.53	5.18	6.08	18.51	31.68	16.13	25.67	26.53	4.46	2.55	6.48	0.32	10.95	11.58	3.30	3.15	1.15	1.84	8.56
Boethius 1	59.57	15.98	11.84	10.78	42.55	14.76	19.34	23.35	7.20	4.34	3.71	0.22	1.44	14.26	2.26	5.25	3.25	1.44	7.67
Boethius 2	57.81	15.38	12.94	13.08	37.61	15.59	19.74	27.06	6.72	4.76	3.87	0.17	0.72	15.80	2.06	6.01	3.03	1.40	7.82
Isidore	57.26	10.50	6.30	23.67	30.22	16.90	24.92	27.96	4.48	4.42	2.72	0.39	0.69	17.01	1.47	3.00	2.70	2.88	9.88

Table 13: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Bede	48.79	11.05	11.24	23.76	21.07	22.33	26.54	30.05	2.55	3.38	1.94	0.75	1.15	9.08	2.05	2.68	1.10	5.51	9.54
Rabanus	59.92	8.10	7.21	21.03	26.47	20.74	26.56	26.23	3.77	3.80	2.50	1.05	1.43	15.56	1.50	4.21	2.19	2.45	9.84
Eriugena	53.57	9.76	13.95	18.92	25.45	22.06	24.63	27.86	4.66	3.50	2.99	1.07	4.10	12.73	3.42	5.72	2.26	2.22	8.95
Anselm	54.71	15.62	16.17	10.12	37.55	13.09	22.15	27.22	9.05	4.53	4.17	0.53	1.83	9.47	0.96	4.48	2.42	0.82	7.64
Abelard	56.81	11.93	13.90	14.90	37.25	15.76	25.14	21.85	6.94	4.23	3.27	0.33	0.97	13.23	2.05	7.11	2.20	1.58	8.21
Guil. de Conchis	51.61	16.86	11.65	17.03	30.17	15.55	24.14	30.14	5.72	3.47	3.68	0.52	0.29	11.84	1.85	4.10	2.93	2.38	8.54
Hugh of S. Victor	55.11	12.93	13.07	13.02	28.73	18.87	26.92	25.47	4.89	4.11	3.00	0.87	2.42	10.34	2.50	5.70	1.50	1.58	9.26
Albertus	61.81	10.29	8.48	15.08	35.03	16.04	22.22	26.70	6.74	5.09	2.41	0.35	0.46	16.84	3.05	4.86	2.73	0.75	8.19
Aquinas	55.38	12.13	13.57	15.99	32.92	18.30	25.23	23.55	6.70	5.11	3.56	0.85	0.57	13.63	2.95	5.62	4.10	1.41	8.27
Roger Bacon	59.46	11.63	9.70	15.10	26.32	19.44	27.55	26.70	4.31	3.63	2.86	0.63	1.73	11.78	2.37	4.58	1.63	1.38	9.18
Lullus	58.87	9.86	8.25	14.28	38.51	13.46	24.27	23.76	8.17	4.94	1.57	1.35	0.27	10.24	2.31	8.09	0.64	1.39	7.66
Duns Scotus	57.25	10.56	10.93	16.79	37.10	14.23	21.81	26.86	6.31	3.84	3.70	0.27	1.37	14.68	2.82	6.86	1.54	1.50	8.11
Ockham	58.25	9.27	10.17	17.40	46.39	11.28	18.60	23.73	7.90	4.29	3.00	0.23	1.12	13.68	3.01	5.31	1.60	1.73	7.82
Copernicus	43.57	16.22	12.86	24.71	18.27	21.58	33.12	27.02	4.52	5.07	2.95	0.38	1.81	13.49	2.44	3.52	2.19	3.35	8.41
Cardanus	51.90	16.71	11.45	16.88	25.59	16.55	25.01	32.84	4.10	3.28	2.20	0.25	2.48	13.79	1.50	2.84	2.82	3.09	9.72
Vesalius	46.67	13.51	9.41	24.63	19.61	26.96	24.70	28.73	1.71	3.54	1.94	0.36	3.44	18.91	1.20	1.78	1.24	3.03	9.20

Table 13: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Suárez	47.63	12.81	19.54	16.03	28.17	16.48	25.94	29.41	5.24	2.89	3.88	0.47	1.39	11.27	2.21	6.74	2.47	2.00	8.48
Galileo	46.73	10.98	8.37	31.54	18.66	17.58	29.72	34.04	3.01	2.23	2.00	0.56	3.99	11.59	3.72	3.38	2.37	3.34	8.88
Vossius	45.90	19.08	16.45	13.45	23.15	18.43	27.42	31.00	3.45	4.30	2.89	0.65	3.11	8.80	1.84	3.75	1.52	1.86	9.26
Descartes	38.67	20.82	18.81	16.92	22.43	20.76	28.03	28.78	3.60	4.15	3.03	0.64	1.85	11.83	1.18	2.70	0.85	1.88	8.75
Spinoza	51.90	10.44	19.23	10.09	34.47	19.70	22.26	23.56	3.85	4.82	2.72	0.81	3.01	13.92	0.70	6.12	1.34	1.60	8.24
Kircher	46.99	9.58	12.44	25.53	16.01	20.22	29.96	33.82	2.20	3.88	1.77	0.95	3.86	8.71	2.10	3.12	0.73	4.23	9.63
Newton	43.29	17.83	6.65	26.47	25.89	20.94	25.13	28.05	3.91	2.61	3.85	0.39	2.97	16.51	2.29	4.78	1.26	3.26	8.57
Kretschmann	41.92	9.38	10.71	27.64	16.40	21.49	27.85	34.25	2.21	2.53	1.66	0.67	6.88	7.19	1.78	5.47	0.88	6.21	9.69
Boyer	53.23	11.34	12.46	16.41	32.92	18.93	23.47	24.69	5.10	3.31	2.64	0.62	3.50	14.32	3.05	7.16	1.84	1.58	9.02
avg	**51.43**	**13.29**	**12.40**	**18.41**	**27.96**	**17.82**	**25.80**	**28.43**	**4.75**	**3.94**	**3.00**	**0.58**	**2.46**	**12.75**	**1.98**	**4.66**	**1.85**	**2.68**	**8.84**
stdev	*6.49*	*3.49*	*3.64*	*5.17*	*7.54*	*3.28*	*3.31*	*3.65*	*1.82*	*0.90*	*0.94*	*0.27*	*2.05*	*2.84*	*0.77*	*1.71*	*0.81*	*1.51*	*0.69*
De interpret.	59.44	12.30	15.80	10.55	43.88	10.80	22.27	23.05	10.12	4.72	4.06	0.09	1.55	9.94	2.02	1.91	3.93	1.04	7.07
De causis	67.82	5.49	5.04	21.52	42.16	10.32	26.75	20.77	10.07	4.63	4.20	1.82	0.38	8.56	2.04	2.26	1.78	1.26	6.80
Argyropoulos	59.86	12.70	17.15	9.05	37.69	10.73	23.13	28.45	8.66	4.22	3.98	0.08	1.20	14.03	1.31	6.35	4.93	1.34	7.69
Ficinus	52.32	9.78	11.20	22.01	23.43	17.75	30.68	28.15	2.90	2.50	2.15	0.66	0.98	11.60	2.90	5.34	1.33	2.55	9.24
avg transl.	**59.86**	**10.07**	**12.30**	**15.78**	**36.79**	**12.40**	**25.71**	**25.10**	**7.93**	**4.05**	**3.60**	**0.67**	**1.03**	**11.01**	**2.07**	**3.97**	**2.99**	**1.55**	**7.70**
stdev	*6.33*	*3.31*	*5.47*	*6.94*	*9.28*	*3.58*	*3.84*	*3.81*	*3.43*	*1.05*	*0.97*	*0.83*	*0.49*	*2.41*	*0.65*	*2.21*	*1.72*	*0.68*	*1.09*

Table 13: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Arithmetic	**52.31**	**15.53**	**6.70**	**20.35**	**32.43**	**15.96**	**26.38**	**25.22**	**5.55**	**3.37**	**3.19**	**0.31**	**1.87**	**13.58**	**2.00**	**4.60**	**2.23**	**2.07**	**7.26**
stdev	*8.94*	*5.14*	*3.62*	*6.69*	*4.80*	*3.44*	*4.85*	*5.59*	*1.03*	*0.46*	*0.71*	*0.23*	*1.17*	*4.14*	*1.10*	*2.07*	*1.36*	*1.08*	*0.60*
100 BC–AD 200	45.28	17.10	15.33	17.10	22.05	15.56	29.79	32.59	3.91	4.04	2.92	1.27	7.82	7.56	1.07	3.46	1.45	3.37	9.36
200–450	52.02	14.94	10.99	16.75	25.11	18.16	29.48	27.26	4.08	3.81	3.31	1.70	4.12	9.05	1.04	3.96	1.87	2.36	8.83
780–900	51.64	13.34	10.89	19.11	23.83	20.06	27.47	28.63	3.56	3.63	3.03	1.65	2.99	10.14	1.36	4.55	1.51	2.93	9.11
1100–1220	51.19	13.40	10.73	19.37	23.96	19.56	27.29	29.20	3.47	3.50	2.99	1.79	3.40	9.58	1.40	4.75	1.42	3.28	9.16
1500–1820	46.44	12.77	14.16	20.88	23.59	18.57	28.22	29.62	3.58	2.66	2.35	1.42	3.88	9.35	1.38	4.24	1.07	3.22	9.27
avg	**49.31**	**14.31**	**12.42**	**18.64**	**23.71**	**18.38**	**28.45**	**29.46**	**3.72**	**3.53**	**2.92**	**1.56**	**4.44**	**9.14**	**1.25**	**4.19**	**1.46**	**3.03**	**9.15**
stdev	*3.19*	*1.75*	*2.17*	*1.71*	*1.10*	*1.75*	*1.14*	*1.97*	*0.26*	*0.53*	*0.35*	*0.21*	*1.94*	*0.97*	*0.18*	*0.51*	*0.28*	*0.41*	*0.20*
Digesta	40.10	18.79	17.41	18.29	23.71	14.11	29.44	32.74	4.49	3.45	0.84	0.47	3.17	9.99	0.77	5.11	1.15	3.75	8.96
Vulgate	58.51	10.61	6.08	19.64	24.42	15.49	33.49	26.59	4.19	3.38	2.85	2.04	6.02	4.60	0.46	4.95	3.12	1.72	8.87
Charter corpus	53.26	10.82	10.90	21.99	19.10	17.96	25.30	37.65	2.16	2.48	1.74	1.71	11.03	5.19	1.88	3.82	0.59	4.06	8.60
Poetry corpus	49.57	11.06	10.78	23.06	25.31	11.30	32.92	30.48	1.99	2.23	1.78	1.54	5.23	4.57	1.35	0.87	0.61	5.49	9.92
Vergil/Ovid	53.10	9.97	9.83	21.95	25.44	10.33	33.05	31.17	2.78	2.08	1.70	1.90	6.13	4.29	1.27	0.64	0.50	5.98	9.90
Scientific poetry	47.95	11.63	13.20	24.07	24.68	14.41	30.75	30.15	2.33	2.39	2.24	0.57	2.13	7.68	1.22	0.88	0.75	4.36	9.68

Characterising scientific Latin texts in contrast to other texts

§5 Tables 12 and 13 have presented numerical data about PoS and features that could be relevant for scientific Latin in light of what was reviewed (chap. 17) for scientific English. They show some traits rather clearly. In general, the composition of PoS differs very strongly between prose and poetry samples. All values for the poetry samples are outside 1 stdev of the benchmark prose samples: poetry has more ADJ, N, and V, but fewer CONJ, PREP, and PRON. Non-scientific poetry additionally has fewer ADV; scientific poetry is inconclusive in this respect. The charters show some traits typical for substandard Latin: high numbers of CONJ, PREP, but also a very nominal language (low V, high N, high ADJ). The Vulgate shows some similar traits (high CONJ and PRON), as do the *Digesta* (high CONJ, though not subordinating ones; high V; low ADJ, ADV, PRON), although these two samples clearly represent very different types of Latin. Within scientific prose, the translations from Greek exhibit some common features (although they are translations of very different texts), in particular more CONJ and PRON, fewer N. This may represent general differences between Greek and Latin. The scientific sample has fewer V, N, and PRON, but more ADJ, ADV, and PREP. CONJ are more common than in the benchmark in many texts, but less so in others, producing an average value close to that of the benchmarks.

The more specific parameters in table 13 also show significant differences between the average of the five benchmark corpora on the one hand and poetry or translations from Greek on the other, and, less clearly, also differences between the scientific texts and the benchmark. Verbal and nominal subcategories (the first eight columns) produce less clear differences than the other parameters. Poetry has fewer SUB but more PTC (and to a lesser extent INF), fewer GEN but more NOM and ACC; the translations more NOM, fewer GEN, more IND, and surprisingly fewer PTC (although this depends strongly on the author). The scientific texts show less clear trends for these eight parameters on average: more NOM, fewer ACC and ABL/DAT. Only the amount of NOM differs strongly; this case is much more common. The verbal parameters are on average within 1 stdev of the five benchmark samples. But many of the individual texts are outside the normal range, some above, some below. The next chapter will try to find groups of scientific writing styles to match such cases.

The twelve more specifically chosen parameters differ more clearly. They were selected from a greater number of similar parameters, many of which did not differ markedly from the benchmark (somewhat surprising in the case of subordinating CONJ and word length, which are the only ones printed). Poetry tends to have lower numbers for all of the values shown, except ABL ABS and entropy, for which it has much higher values (ADJ-SUF, PRON:POSS, 1st SG are within normal range); the translations show quite the inverse behaviour (except

REL). The scientific texts behave more or less like the translations from Greek, except that REL and 3rd PAS are also higher but subordinating CONJ are within range and N-SUF are lower. Parameters that differ strongly in both this scientific corpus and the arithmetic one (described in the next chapter, but average numbers are already included in the tables above) are ESSE, 3rd PAS, ADJ-SUF, and REL (all higher) and 1st SG, PRON:POSS, ABL ABS, and entropy (lower). As a first result, we may consider these values as significantly different in scientific Latin.

Among the three out-group corpora, not very surprisingly the charters often use the first person singular and the indicative as well as the ablative and especially the ablative absolute. If the many 'unknown' place and person names were included, the numbers of ABL might rise even further. They also use PTC more often than usual. The *Digesta* use SUB and INF conspicuously often; quite the opposite is true for the Vulgate, which on the other hand betrays its Greek origin by the high numbers of modifiers. Interestingly, suffixes are rare.

Among these data, a progression can often be observed: poetry – scientific poetry – general prose (five benchmark corpora) – the scientific texts – the five translations from Greek. Sometimes the arithmetic sample from chapter 20 below follows at the end, as can be seen in table 14.

Table 14: Progressions for some values. Green marks the maximum value, red the minimum value (not including the arithmetic sample).

	Poetry	Scientific poetry	5 benchmarks	Sample of 40 science texts	Translations from Greek	Arithmetic (chap. 20)
ADV	7.2	8.5	9.0	9.7	13.0	8.3
CONJ	7.3	8.0	9.9	9.9	12.0	10.2
N	30.5	29.7	25.7	24.5	20.7	19.7
PREP	4.4	5.3	8.3	9.1	8.9	11.1
V	24.6	24.3	22.9	21.9	16.2	20.8
ESSE	2.0	2.3	3.7	4.8	7.9	5.6
REL	2.2	2.4	3.5	3.9	4.1	3.4
PRON:POSS	1.5	0.6	1.6	0.6	0.7	0.3
1st SG	5.2	2.1	4.4	2.5	1.0	1.9
3rd PAS	4.6	7.7	9.1	12.8	11.0	13.6
ADJ-SUF	1.4	1.2	1.3	2.0	3.0	2.0
N-SUF	0.9	0.9	4.2	4.7	4.0	4.6
Modifiers	0.6	0.8	1.5	1.9	3.0	2.2

Table 14: (continued)

	Poetry	Scientific poetry	5 benchmarks	Sample of 40 science texts	Translations from Greek	Arithmetic (chap. 20)
ABL ABS	5.5	4.4	3.0	2.7	1.6	2.1
Entropy	9.92	9.68	9.15	8.84	7.70	7.26

For some parameters the scientific texts show extreme values (which would seem to be especially typical for scientific texts): PREP, PRON:POSS, 3rd PAS, N-SUF; often the arithmetic sample shows even more extreme values in these cases. The scientific poetry text sample tends to behave like other poetry. Only rarely does it behave more like other scientific texts; this is especially the case for PRON:POSS and 1st SG. The next chapter (chap. 19) will try to name subgroups in the general scientific corpus according to characteristic parameters and thus come back to types of Latin encountered in part 2 above.

§6 Principal component analysis (PCA)[40] is now applied to these data in order to plot them and to render these (or other) groups more clearly visible. The closer points are situated on the plot, the more similar these texts are in the parameters considered. The idea of PCA is to project multidimensional data onto two dimensions in the 'best' way, that is, preserving as much of the variation as possible. In order to achieve this, the *n*-dimensional data – for instance consisting of *n* of the above parameters for each sample – is transformed orthogonally in the direction of the maximal variation within the data, producing the first dimension, the second dimension is the dimension with the highest variation under the constraint of being orthogonal to the first one (and so on, but usually only two dimensions are plotted). 'PC1' in the plots thus shows this first and most significant component; the accompanying value in the graphics the percentage of the entire variation; 'PC2' the second component. In our samples, these two 'best' dimensions together tend to represent between 60 % and 70 % of the entire variation, in other words only about two-thirds of the entire variation. The components themselves are made up of linear combinations of all *n* parameters and, therefore, do not represent an intuitively meaningful quantity.

40 Clustvis (https://biit.cs.ut.ee/clustvis), a handy free online tool based on R, was used. The tool automatically turns values into standard scores (average 0, stdev 1), so no prior calculation of these is required.

The following plots depict the forty scientific texts (numbered chronologically) and those translated from Greek (blue) together with the five benchmark samples (green, boxed); the out-groups poetry (red), *Digesta*, charters, Vulgate (italics); and the corpora that will be studied in chapter 20 (arithmetic, historiography, scientific poetry, medicine, all in pink). Additionally, there are three groups of texts from within the forty texts named ‘classical’, ‘scholastic’, and ‘new’ science (also pink).[41] They may represent especially typical subgroups. Despite the fact that Latin is (rightly) seen as a very homogeneous and stable ‘fixed’ language, clustering separates some major groups fairly well. The PoS work quite well for grouping, the values that were found to be specific for scientific texts even better. What we would expect from a ‘good’ clustering separating scientific texts from others is that

- the poetic out-group will be separated from the rest (and Vergil/Ovid close by);
- the Vulgate will also be separated from the rest, although it will be expected to influence some of the mediaeval scientific texts;
- the large prose benchmark samples will be reasonably close together, especially on the one hand the three from the Middle Ages and on the other hand possibly the classical and the Neo-Latin ones.

Of course, we also have some preconceptions from the scientific approaches and periods described in part 2 above: for instance, scholastic texts are expected to be grouped together.

First, a simple two-dimensional plot N against V is presented (fig. 34, without PCA). Such a simple plot can already separate the metrical texts quite well (top right), and puts the benchmark corpora approximately in the middle, the Greek translations in the bottom left, and the scholastic and arithmetic texts centre-left. The average value for all forty scientific texts in the sample (‘avg 1–38’)[42] lies slightly to the left of the benchmark (indicating fewer nouns), close to the medical sample and to the Vulgate. The historiographical sample lies on the other side, toward the poetic texts. Some technical *artes* authors also group to the right (more N): especially Pliny, Rabanus, Vitruvius, Bede, Isidore. In general, it would seem that ‘new’ science texts use fewer V, scholastic ones (unexpectedly) fewer N, juridical texts (*Digesta*, Gaius, *Pauli sententiae*) more V, and at least *Pauli sententiae* more N.

A more sophisticated plot (fig. 35) for the same texts uses all seven PoS (ADJ, ADV, CONJ, N, PREP, PRON, V); the seven-dimensional data is optimally fitted to

41 They comprise respectively Varro, Cicero, Seneca; Albertus, Aquinas, Ockham, Suárez; Copernicus, Vesalius, Galileo, Newton.

42 A single number is used for the two Boethius texts and for the two juridical primary texts, so the numbering reaches only 38, even though there are 40 texts.

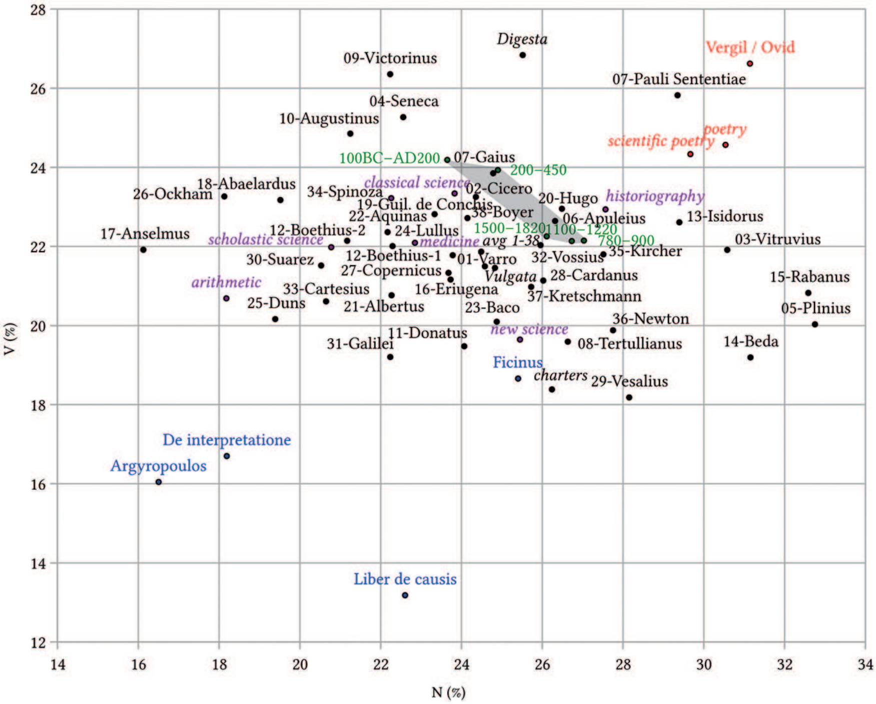

Fig. 34: Simple N vs V plot. Details in the main text.

two dimensions using PCA. Interestingly, the plot is quite similar to the simple N vs V plot. Again, it sets the poetical texts quite clearly apart from the rest. The translations from Greek, too, are on the other side of the plot. The scientific texts tend to be below[43] the benchmark samples, though the juridical and the 'classical' ones do not. The scholastic ones are again more to the left, the technical ones and those of the Scientific Revolution to the right. All in all, these PoS results seems interesting, though not very distinctive for scientific Latin in general.

In a further plot (fig. 36), all eleven parameters introduced above as potentially typical for scientific Latin are used: ESSE, REL, CONJ:S, PRON:POSS, 1st SG, 3rd PAS, ADJ-SUF, N-SUF, modifiers, ABL ABS, entropy. The non-scientific texts are now much more clearly separated from most texts of the scientific sample; indeed, none of them are plotted within the greyed-out area enclosing the five non-

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43 The coordinates in these plots are relative values without an intuitive meaning, so 'up', 'down', and similar terms are merely relative terms. The plots' orientation was chosen to be such that the translations from Greek were always at the bottom left in order to facilitate comparison.

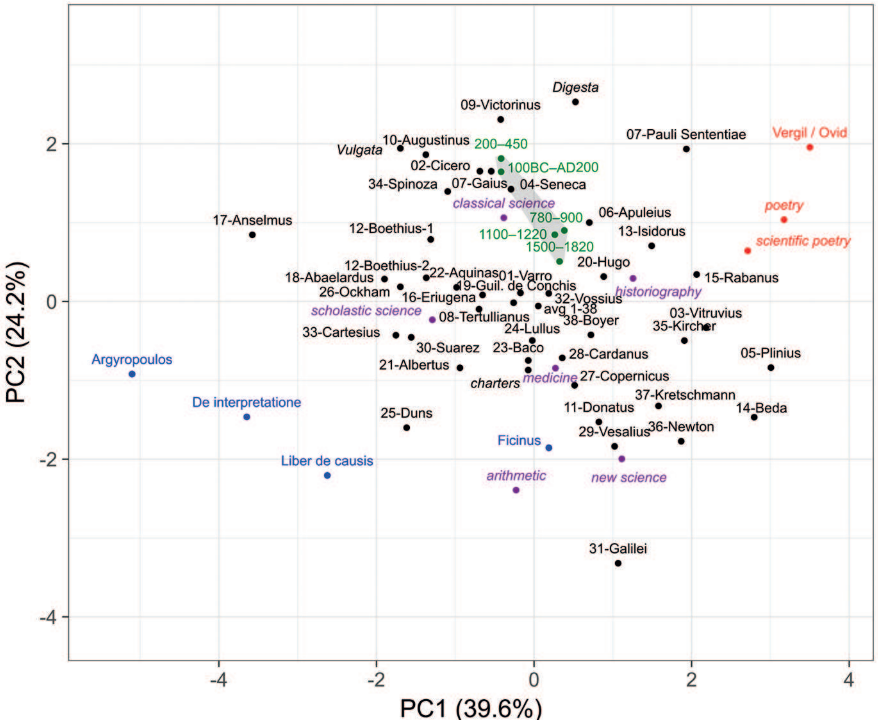

Fig. 35: PCA plot using the amounts of the seven PoS.

scientific benchmark samples. To the far left, the scholastic texts (including their 'father' Boethius) group quite neatly. Neo-scholastic ones (Suárez and Boyer) are between them and the centre of the plot. Many texts from Antiquity have a tendency to remain close to the five benchmark samples; in other words, their language is less distinctive than that of later scientific texts, for instance Varro, Cicero, Augustine, Seneca, Donatus. The two Neo-Latin human science texts (Kircher and Kretschmann), the charters, and historiography are located at the other side of the plot, close to the poetic texts. The translations from Greek are scattered all over the left-hand side of the plot, though the humanist translator Ficino ends up away from the others. Technical/encyclopaedic texts end up at the top centre (Vitruvius, Pliny, Bede, Isidore, Cardano, Vesalius, Galileo, Newton), the Vulgate at the bottom, far apart from the rest. The scientific corpus as a whole and the arithmetic corpus studied in the next chapter are situated in the centre together with some apparently 'inconspicuous' scientific texts: Gaius, Eriugena (surprisingly), Guilelmus de Conchis, Hugh of St Victor, and Roger Bacon, among others. Marius Victorinus, Anselm, and Lullus lean toward the translations from Greek.

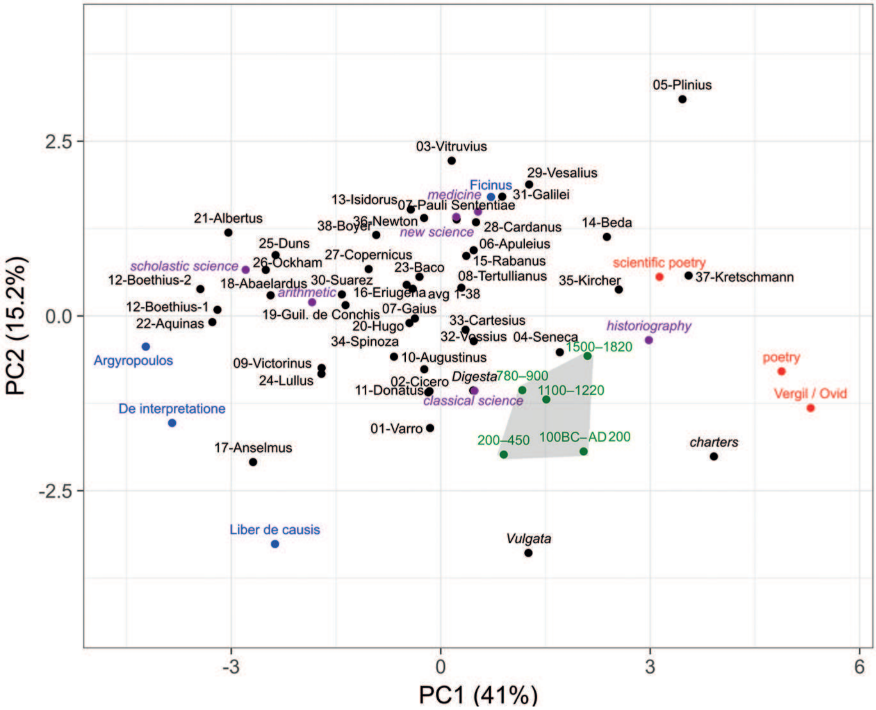

Fig. 36: PCA plot of all eleven parameters from the right half of table 13.

In the hope of getting an even neater result, now (fig. 37) only those parameters are used that differ at least 3 stdevs for the average of the forty scientific texts from the benchmark average. These are NOM, ESSE, PRON:POSS, 1st SG,[44] 3rd PAS, ADJ-SUF. The five benchmark samples remain together (Varro, Cicero, Seneca, Augustine close to them); the poetry, Vulgate, and charter out-groups are far to the right. Technical texts together with texts from the Scientific Revolution are quite neatly apart from one another and from the benchmark, but it is the scholastic ones that are most clearly separated from the rest. Medicine and arithmetic are in between, medicine closer to the texts of the Scientific Revolution, arithmetic to the technical ones. Thus, the more practical or experimental sciences stay together, in contrast to the more theoretical ones. Again, early modern human

44 Obviously, 1st SG cannot be lower than 3 stdevs of 4.44 ±1.93, which is due to the high stdev in the benchmark samples, which is again due to much higher amounts of 1st SG forms in the classical benchmark sample than the others. The scientific texts are in many cases very much lower (below 1), so including this value seemed warranted.

scientists and historiographers are close to one another and the benchmark samples; the charters are now somewhat further off.

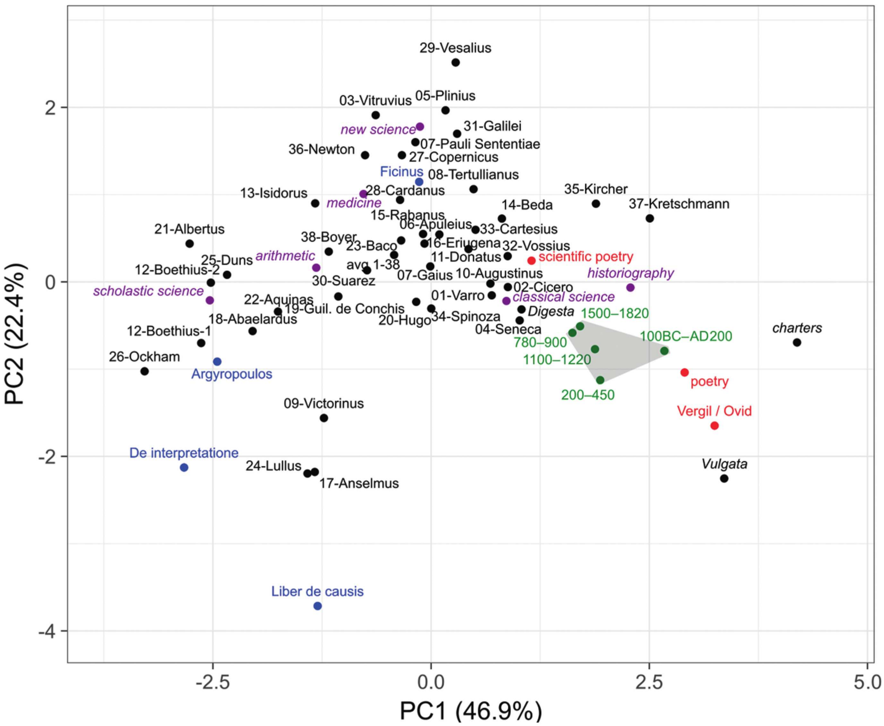

Fig. 37: PCA plot of the parameters for which the average of the scientific sample differs more than 3 stdevs from the benchmark: NOM, ESSE, PRON:POSS, 1st SG, 3rd PAS, ADJ-SUF.

For a final plot, the values whose averages in the forty scientific texts *or* in the arithmetic sample differ more than 3 stdevs from the benchmark were used (see fig. 38), a set of parameters that will be used again in chapter 20. These are ten parameters: ADJ, N, PREP, NOM, ESSE, PRON:POSS, 1st SG, 3rd PAS, ADJ-SUF, entropy. Many things remain the same as in the previous plot, but the groups of scholastic versus Scientific Revolution vs 'normal' texts become clearer (highlighted by green lines).[45] The arithmetic sample is now clearly within the scholastic group.

45 Moving the near-vertical line somewhat further right would include Guilelmus de Conches, Suárez, and Spinoza in the scholastic group. These authors do indeed seem to lie somewhere between scholastic and more 'normal' Latin.

Scientific texts from Antiquity and human science texts tend to remain close to the benchmark samples. The Vulgate and the poetry samples separate clearly from the rest, but in another direction. In all plots, the juridical texts (*Digesta*, Gaius, *Pauli sententiae*) do not cluster close together. They belong to quite different genres, and it seems that jurisprudence – in Antiquity the most Roman of all sciences, as has been pointed out (chap. 8 §12) – used heterogeneous language in different genres, at least more so than other sciences. In this plot, by far the main part of the information (40.6 %) lies on the *x*-axis; the *y*-axis displays only 19.7 %, not much more than the third, not depicted, dimension would. The most robust result is, therefore, certainly found on the *x*-axis; the scholastic texts are therefore the most distinct ones in the sample.[46]

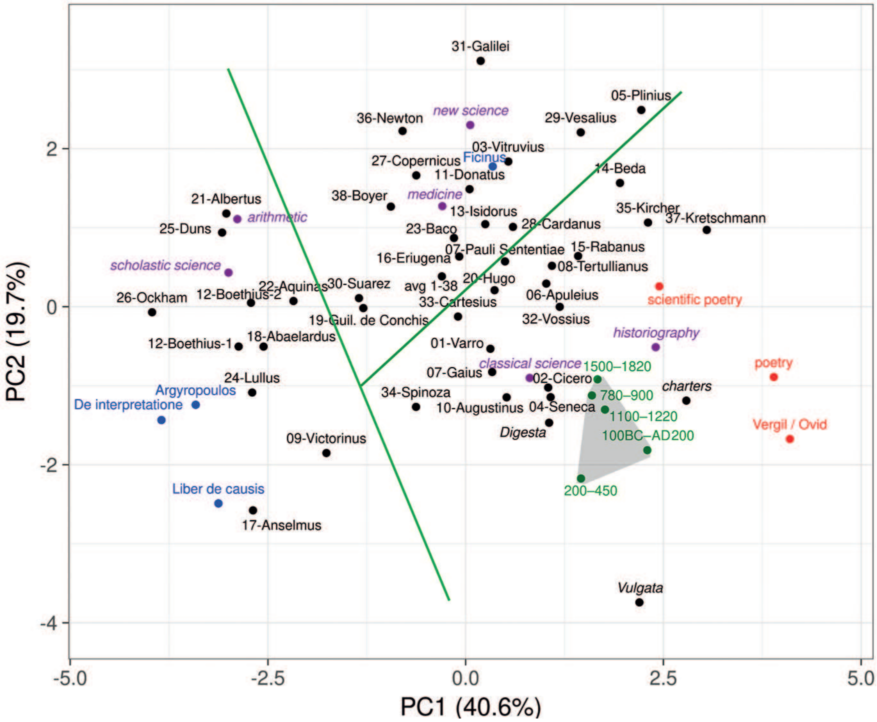

Fig. 38: PCA plot of the ten parameters for which the average of the scientific or the arithmetic sample (treated below, chap. 20) differs more than 3 stdevs from the benchmark: ADJ, N, PREP, NOM, ESSE, PRON:POSS, 1st SG, 3rd PAS, ADJ-SUF, entropy.

46 PC1's vector components: ADJ: 0.03, N: 0.39, PREP: −0.23, NOM: −0.42, ESSE: −0.44, PRON: POSS: 0.26, 1st SG: 0.28, 3rd PAS: −0.25, ADJ-SUF: −0.21, entropy: 0.43. Thus, ADJ is the piece of information that contributes least, ESSE, NOM, and entropy the most.

§7 Another approach that can be used to group the texts is stylometry. Although it was conceived to solve questions of authorship, this method may also produce meaningful results for distinguishing scientific types of language. The most common *n* tokens (words or lemmata) in each text are compared.[47] Their frequencies are stored in a vector, and the distance between the vectors corresponding to the text samples is then calculated.[48] The result is a clustered tree view based on a distance matrix calculated from the frequencies. This approach thus compares the core vocabulary of different texts. Figures 39 and 40 show a plot for the 100 most common words and lemmata respectively. In order to lessen the impact of specialised disciplines' specific vocabulary, a culling value of 80 % was used, which means that only tokens present at least once in at least 80 % of all samples (i.e. 46 of the 58 ones used) are taken into consideration. Tentative names for groups are superimposed on the plots.

The results are relatively similar to the previous PCA plots (bearing in mind that very different parameters are used). Some groups form more as would be expected in the word-based plot, some in the lemma-based one. The non-scientific metrical texts (red) cluster together in both plots, the benchmark samples only partly: the antique sample is found close to Cicero in both plots, not together with the other benchmark samples. The Vulgate and charters cluster together with the other benchmark samples as non-scientific texts. Scholastic texts tend to separate most neatly from the rest; they cluster together with the translations from Greek (except, again, Ficino). Strangely, Aquinas is found somewhere else in the lemma-based plot, the neo-scholastic author Boyer in both. The three juridical texts cluster together much better than in the PCA plots. In both plots, there are two groups comprising mostly natural-science authors and human-science authors respectively. In the word plot, Augustine and, surprisingly, Eriugena end up with the non-scientific texts. Changes in the sample size (i.e. adding or removing texts) can produce strange changes (not shown). Changing the number of tokens considered, on the other hand, leaves the result quite stable. In general, it would seem that the smaller units are usually relatively stable and tend to correspond well to expectations, but the uppermost bifurcations in the tree are not very

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47 I used the *stylo* package for R (as described in Eder, Rybicki & Kestemont 2016). 'Unknown' lemmata were, again, removed from the samples.

48 The simple and intuitive 'Classic Delta' distance first proposed by Burrows (2002) was used. To calculate it, values are standardised to standard scores, then the distance between two vectors is defined as the length of the vector of the one minus the other in Euclidean space. Evert et al. (2017) study different distances and find that the cosine distance (defined as the cosine of the angle between the two vectors) tends to outperform the others. Applied to our sample, the differences were minor (results not depicted).

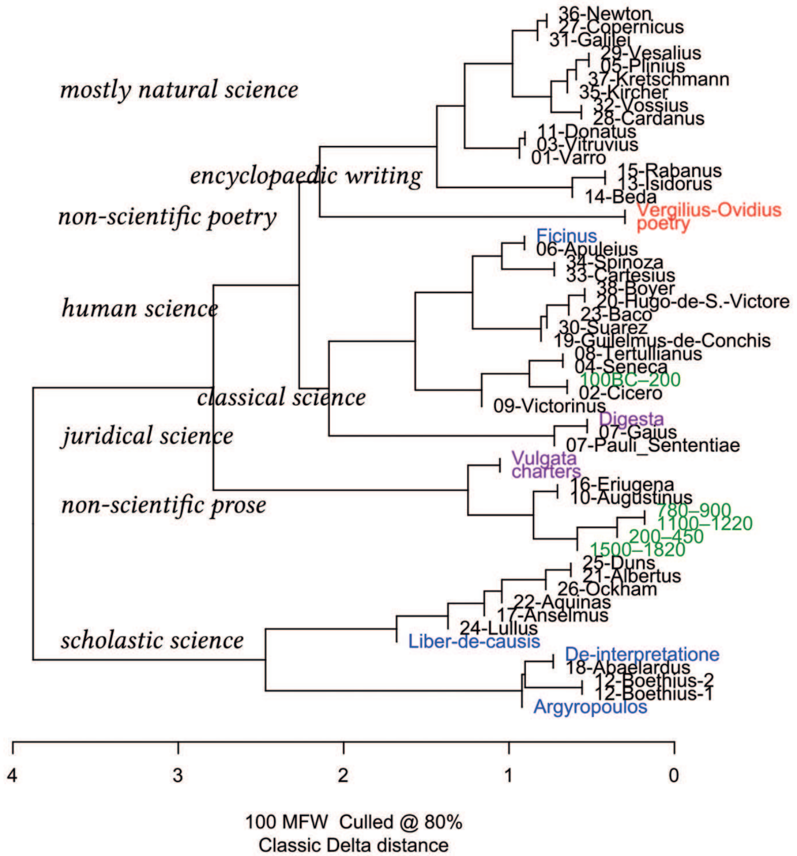

Fig. 39: Stylometric clustering of 100 most frequent words.

stable. In fact, with changing parameters, they tend to shift easily, as do some, apparently not clear, texts. On the whole, these results based on the core vocabulary seem less convincing and stable than those obtained above using grammatical categories and PCA.

A word of caution may be in order: the plots in this chapter are based on very basic values that were determined automatically. They are only as good as the input values. The approach is relatively primitive. If it were possible to automatically generate confident syntactic trees and compare them, the results would become more trustworthy and telling. That said, it is all the more remarkable to see that such basic values as the ones used yield results that are surprisingly close to what a literary critic would assess the Latin types of language of these authors to be. Of course, there are cases that do not square well; they may be interesting in making us think about why certain authors end up in different places than expected. Although this approach can quantify differences in scientific (or other) style,[49] it certainly cannot supplant stylistic evaluation by critics, which is based on much more complex ‘input’ (the reading and understanding of the texts) – but it may enrich it and suggest new ways at looking at it. The next chapter compares the findings with non-computational impressions.

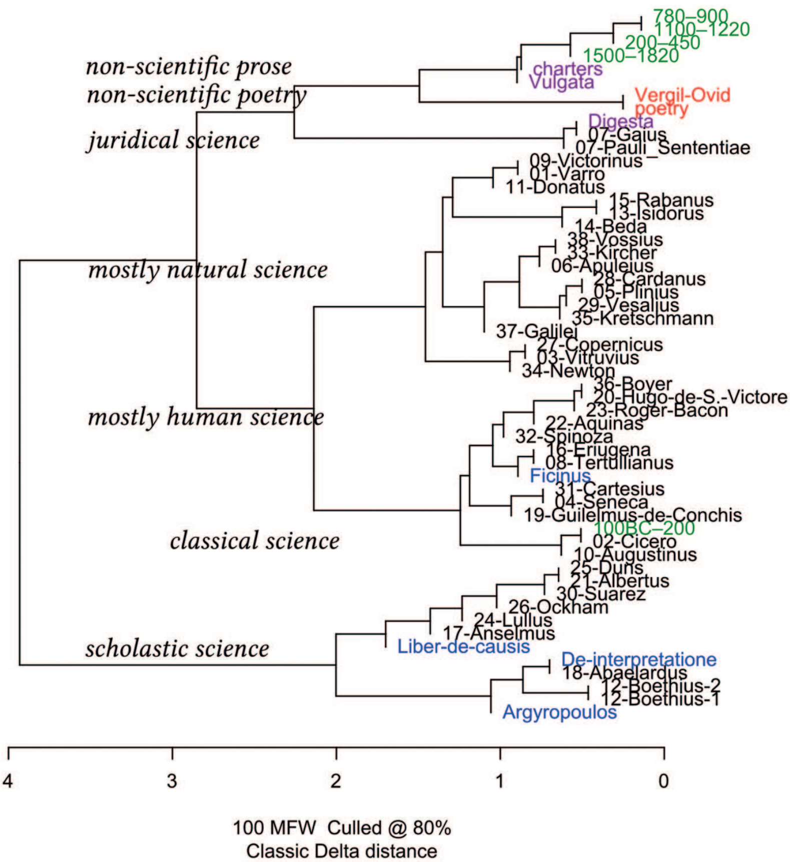

Fig. 40: Stylometric clustering of 100 most frequent lemmata.

49 We use the term ‘style’ in the following in its most comprehensive sense, as the entire linguistic form not directly related to the content.

19 Conclusions on the Latin used in scientific texts

§1 The computational results from the previous chapter can now be compared with the observations about the language used in scientific communication assembled in part 2 of this book. Through its long and varied history, Latin has known many different styles and registers. In Antiquity, for instance, we can speak of Ciceronian, 'bombastic' (see chap. 8 §11), or Christian Latin. Besides many individual registers and styles, the Latin Middle Ages developed its own kind of Latin koine,[1] which, though different from classical standards to some extent, still had its own relatively fixed and stable standards, first described in detail by Stotz (1996–2004). Its syntax and vocabulary have more in common with Late Antiquity with a good dose of Christian Latin, than with Classical Latin. In the Middle Ages, some special types of Latin, such as Hiberno-Latin or scholastic Latin, are easy to discern too. In early modern times, humanist Latin contrasts with more pragmatic Latin. Those are but a few examples. Approaches to science have also changed significantly in the two thousand years reviewed in part 2. We found seven epochs. In some of them, language and approaches seem to have remained quite constant (the time of the *artes liberales,* university science, Scientific Revolution); those in between were rather more diverse (Roman Antiquity, twelfth century, Renaissance). Some attempts to group scientific Latin texts on the basis of all the data we have so far encountered are now presented: based on the last and apparently most convincing PCA plot (§2), on Latin style (§3), and on Greek scientific models (§4). Typical example texts are then presented and analysed (§§5–6). The discussion of differences that are due to scientific topics is postponed to chapter 20 §8.

§2 The numbers and plots in chapter 18 have shown that some of these rather crude grammatical parameters distinguish surprisingly well between scientific and non-scientific Latin prose. But, as expected, it has also become clear that there is no linear development of scientific prose through time, because Latin is a language with a very good memory. So, quite in general within Latin it has always been possible to imitate older authors, and traditionalists who are against all novelty were always on hand to rein in new developments. Nonetheless, there are also new norms being developed over time. The data above have produced the following candidates (from left to right in fig. 38).

- The 'scholastic type', including neo-scholastic authors such as Suárez and (less clearly) Boyer, forms a clearly defined group. High numbers: ADV, N,

1 As Chiesa (2017) puts it.

https://doi.org/10.1515/9783110745832-020

PREP, IND, ESSE, REL, modifiers; very low: V; low: 1st SG. Similar, often even more extreme, numbers were found for the next type.

- The 'Greek translator type', including the translations of *De interpretatione* and *Liber de causis,* and that by Argyropoulos. Very high: modifiers; high: ADV, CONJ, PRON, IND, NOM; low: N, V, GEN, ADJ-SUF, N-SUF. Some translators have high numbers of PTC (Greek uses them a lot), some seem to avoid them consciously. The humanist translator Ficino does not fit into this group.
- The 'encyclopaedic-technical type', Pliny, Vitruvius, Isidore, Bede, Rabanus. Low: PRON, ADV, INF, CONJ:S; (relatively) high: N, PTC, entropy.
- 'Scientific Revolution, natural sciences': Copernicus, Vesalius, Descartes, Galileo, Newton form a not very clearly defined group in our data. Low: N-SUF, ESSE, modifiers (all three can be seen as influences of humanism); less low: V; low: NOM. The arithmetic sample used in chapter 20 clusters between these texts and the scholastic ones.
- 'Scientific Revolution, human sciences' or 'modern academic Latin': Vossius, Kircher, Kretschmann, sometimes the historiography sample and the charters. These texts are even less clearly defined; they are not too far removed from the non-scientific benchmark samples. Relatively high: PTC, ABL, entropy; often high numbers of ABL ABS.
- The 'antique type' (Cicero, Seneca). Low: SUF, esp. N-SUF; high: ABL ABS; in general staying close to non-scientific Latin. The sample of scientific poetry from chapter 20 groups quite close to these prose texts in the plot. But this seems to be an artefact: it is more the case that these texts mix features from non-scientific poetry (even further to the right in the plot) and from scientific prose texts, which will explain their position. Typical values go with normal poetry (low: CONJ, PREP, SUB, GEN; high: N, PTC), a few with the average for the scientific texts (1st SG, POSS; 3rd PAS in between).
- A 'juridical type' (Gaius, *Pauli sententiae*, *Digesta*) also remaining relatively close to the non-scientific benchmark can be postulated. Low: ADJ; high: INF, ABL/DAT; low numbers for ADJ-SUF but high ones for N-SUF. Two out of three of these texts also have low ADV, high CONJ, and high numbers of ABL ABS. In general, it seems that juridical language in Antiquity was quite varied: the three texts in the sample usually do not cluster very closely together.

The similarity between scholastic and Greek translation texts does not come as a surprise: after all, the scholastic type can be said to begin with Boethius' translations of Aristotelian Greek. Interestingly, the above groups fit in quite well with the following epochs treated in part 2: university science (chap. 11), twelfth-century translators (chap. 10), *artes liberales* (chap. 9), two types corresponding to the Scientific Revolution (chap. 13), and two to Roman science (chap. 7). Non-translating authors from the twelfth century (Abelard, Anselm, Guilelmus de Conchis, Hugh of St Victor), as well as those of the Renaissance (Cardano, Copernicus, Vesalius, the translator Ficino) do not exhibit similar traits among one another (they were already found to be rather heterogeneous in part 2 above). Some authors seem to have quite their own type of Latin: Varro, Apuleius, Tertullian, and Lullus can be mentioned. Of course, some authors also fall rather in between such groups; for instance, Cardano sometimes goes with the tentative encyclopaedic-technical type, sometimes with the natural science type, or Vossius is often atypical for the modern human science group.

§3 Part 2 has shown some rather clearly disparate stylistic approaches among the authors treated, unrelated to their scientific approaches. The following ones seem to be deductible from our texts.[2] The list is arranged chronologically by first exponents; examples below (§4) will provide more concrete data.

(i) 'Hexametric'. A 'scientific poetry' text sample that will be very different from the rest of the sampled texts will be studied further in the next chapter. Lucretius decisively shaped the form and style of didactic and scientific Latin poetry. The hexameter is mostly used, but this kind of didactic poetry clearly differs from other genres using it (such as the epic). The hexametric approach became mostly didactic after an initial phase in which leading scientific innovation was communicated in it in Greek by authors such as Parmenides and Empedocles (see chap. 7 §2).

(ii) 'Rhetorical'. A rhetorical approach to presenting scientific material can be said to have been the standard approach in Roman Antiquity. The Latin rôle model was certainly Cicero; authors such as Seneca, Quintilian, or Augustine followed, as well as some historiographers. These authors were especially intent on teaching the reader dialectically. Didactic dialogues are common, and new words are avoided. This way of writing tends to remain rather close to non-technical Latin, as an orator will not wish to put off his audience with, for instance, unusual terminology. The concern for the beauty of the text sometimes seems to outweigh that for scientific precision. Humanists strove to return to such a style, but it remained rather rare among scientific writers due to its obvious disadvantages in precision and flexibility; still, there are some writers using it in all epochs, for instance Vesalius in the sixteenth century, but after the twelfth century this style was mostly confined to popular science. In Greek a similar approach was used by Plato (chap. 7 §4).

2 Greek-translation Latin is not considered here as it is not genuinely Latin, although it influenced scholastic Latin decidedly.

(iii) 'Plain'. The first surviving, and most important, author for what might be called plain, unrhetorical, matter-of-fact scientific Latin is Pliny. Later technical and encyclopaedic writers sometimes use similar Latin (Vitruvius to some extent, Isidore, Bede, Rabanus). This plain approach toward language, concentrating fully on the scientific content, may be seen as especially fit for the task. However, later scientists will realise that clear and deliberately employed syntax and well-chosen vocabulary are important for conveying difficult content: the plain approach was, therefore, largely superseded by the more technical and Hellenised scholastic approach after the advent of the universities in the thirteenth century, although some later encyclopaedic authors such as Cardano use a similar approach again. A Greek model can be seen in Alexandrian technical tracts, for instance grammatical ones. Below (chap. 21 and table 22), it will be seen that 'medical Latin' is a special subgroup of this approach. Quite similar to that of Pliny, it represents the language of a more practical science. Among medical writers, Celsus may be rather atypical, as he hardly used Greek terms and did not coin Latin ones frequently; later authors are quite free with new terminology.

(iv) 'Bombastic'. Some scientific authors have used bombastic Latin since the second century, for instance some neo-Platonists such as (in some works) Apuleius or Martianus Capella, especially in his mythological framework, among early Christians especially Tertullian. Their unusual bombast can be concentrated in their vocabulary or consist of complicated and often ambiguous syntax; in addition, there are metaphors, wordplays, and lots of words from Greek and possibly from other old and venerable languages. All of this produces a rather hermetic and inaccessible Latin, and remained rather the predilection of a few scientific writers. Its innovative vocabulary reminds one of Democritus (chap. 7 §2).

(v) 'Scholastic'. A scholastic approach could be clearly seen emerging during the twelfth century, although it had a conspicuous predecessor in Boethius, especially in his second Porphyry commentary. This language is very much logically structured, it contains many new coinings, often from Aristotle's translated Greek, and tries to keep them unambiguous, thus relying strongly on Aristotle's lecture style (chap. 7 §5). This kind of language is syntactically straightforward and not afraid to coin new terms; both these points serve the aim of making things clearer. In contrast to the encyclopaedic type, there is a special emphasis on logical stringency. This will be the most innovative type of Latin for the sciences, and the most important one. Typical authors used in our sample were Aquinas, Albertus, Duns, Ockham, and in some respects even more the translations from the Greek of the *Liber de causis* and *De interpretatione*. Neo-scholastics may have been somewhat less daring in their language, but the approach clearly remains the same (Suárez, Boyer). This is the first Latin approach to language that would seem to correspond to a Greek scientific *Denkstil* in being rigorous and yet flexible enough for science.

Users of both the rhetorical and the mathematical types attacked its capacity to support empty disputation and its ‘ugliness’. It is indebted to Aristotle.

(vi) ‘Mathematical’. The Greek rôle model of this approach is clearly Euclid. As there is no extant Euclid translation before the twelfth century, such texts tend to appear late in Latin: Copernicus, Kepler, Newton, and many of the texts in the arithmetic sample studied in the next chapter. Structuring of the content into theorems, proofs, and the like is typical for it; the texts are often accompanied by tables, charts, figures, and formulas. The syntax is simple but rigorous; there is a conspicuous technical vocabulary. In general, it can be said to be a formulaic type of language (see chap. 22, §4). The language obviously changes with the increasing formalisation of mathematics. Newton may be the best-known, typical representative of an advanced state of this type of language. It would seem to be the ancestor of today’s vernacular language of the mathematical natural sciences.

(vii) ‘Modern academic’. It would seem that only toward Latin’s demise in the seventeenth and eighteenth centuries does there seem to arise a consensus about what scholarly Latin is supposed to look like. A kind of mixture of the scholastic and the mathematical approaches, here and there with a pinch of rhetoric, apparently became standard in the less mathematical sciences. On the one hand, this language does strive for grammatical correctness according to classical rules, and to avoid excesses in word formation (unlike the bombastic and scholastic styles), but rhetorical syntactic excesses are also avoided and the rhetorical disdain for *nova verba* is given up. Greek loanwords, in particular, are frequent. Typical authors were Vossius, Kircher, and Kretschmann, or countless dissertations from the seventeenth to the nineteenth centuries (not included in our samples). This academic style may be the most pragmatic scientific Latin. It could have served very well as an international auxiliary for scientific communication. This seems to be a genuine Latin approach; there does not seem to be a Greek model for it.

This list of types of scientific Latin will not be exhaustive: some authors and some fields would deserve their own labels and would require further study. In some cases, it is conspicuous that there is no typical approach in some groups of writers. This is especially the case for juridical Latin, which does not seem to be homogeneous, and there is neither a clear ‘humanist’ or early modern approach in science, nor a single Jesuit approach: Boscovich wrote, despite his mathematical topic, a rather rhetorical Latin, Boyer a clearly neo-scholastic one, others normal modern academic Latin (such as Orlandini; see chap. 20). It would seem that these approaches correspond to *Denkstile* concerning the relation between language and knowledge. This will be further pursued when discussing examples below.

These styles of rendering science in the Latin language fit in quite well with the computationally determined language styles listed above (§2); only the bombastic style proves hard to make out clearly. Various early modern and late academic styles are also hard to discern.[3] In the time of the Scientific Revolution, it was more and more the case that only two styles remained valid for serious science: the mathematical and the modern academic ones.[4] Indeed, an ever more perceptible differentiation between mathematical and human sciences in the times of the Scientific Revolution seems to become apparent. Unfortunately, very few such late academic Latin texts have been digitised yet. It would be interesting to study a sample of such texts separately. The number of available digital texts will become much larger with the completion of the Noscemus project (Innsbruck).

All but the last of these Latin scientific styles can be linked to Greek models. The single most important factor in the development of Latin as a language of scientific communication was certainly influence from Greek, providing new vocabulary and often also affecting syntax and textual grammar, not to mention its obvious epistemic input in most sciences. The three Greek models producing the most successful approaches to language used in science stem from Plato, Aristotle, and Euclid. These correspond roughly to the rhetorical, scholastic, and mathematical approaches in the list above. This classification and its ways of dealing with words for new things are further explored below (chap. 21). The importing of science from Greek into Latin will be pursued below (chap. 24 §5).

§4 There is no doubt that technical vocabulary and syntax are the two most conspicuously different aspects of scientific language. In extreme cases, single words may already be indicative of a particular type of language. The PREP *secundum* all by itself can act as a marker for scholastic texts: its frequency in the general corpora is on average 0.87 ±0.51‰; the following texts from our sample use it more than 3 stdevs more: Ficino (2.45), Boethius 2 (2.46), Boyer (2.50), Suárez (2.75), *De interpretatione* (3.22), *De causis* (4.87), Ockham (3.84), Abelard (7.11), Roger Bacon (4.32), Duns (7.14), Aquinas (7.48), Albertus (8.78) – precisely the scholastic authors. Interestingly, the less scholastic first commentary of Boethius ('Boethius 1') hardly uses it (0.15). However, in later times this ceases to be a very good marker, as writers after the Renaissance were aware that this is an 'ugly' scholastic word and may have consciously avoided it. In order to corroborate and illustrate the seven approaches of scientific Latin identified above (§3), a typical sample of each is now presented and analysed in terms of some of the more conspicuous

3 In both cases, having more available data might change the picture.
4 And in some 'neo-scholastic' fields also the scholastic approach (chap. 11 §8).

features encountered above: technical vocabulary,[5] especially formed by the suffixes considered above (chap. 18 §2), Greek loanwords, syntactic nexuses (shown by highlighting linking conjunctions and adverbs), MODIFIERS, the ~~relative pronoun~~, and the verb esse, besides parameters that were noted to be rare in scientific Latin (chap. 18): **first person and possessive pronouns**. Texts involving the Moon in some way or other were chosen to illustrate the types of Latin, by authors who seem especially typical for each approach. All the authors have been encountered above in part 2.

(i) Lucretius V.705–736, ed. Ernout, vol. 2, p. 76. This passages discusses explanations of the lunar phases.

Luna potest solis radiis percussa nitere	It may be that the Moon shines hit by the Sun's rays
inque dies magis <hoc> lumen conuertere nobis	and day by day she turns this light more toward us
ad speciem, quantum solis secedit ab orbi,	to see, the more she recedes from the Sun's orb,
donique eum contra pleno bene lumine fulsit	until facing him opposite she shines in full light
atque oriens obitus eius super edita uidit;	and coming up rising on high has seen his setting;
inde minutatim retro quasi condere lumen	then by and by she must as it were hide her light
debet item, quanto propius iam solis ad ignem	again, the more she glides closer to the Sun's fire
labitur ex alia signorum parte per orbem;	from other parts of the zodiac on her orbit. This
ut faciunt, lunam qui fingunt esse pilai	is what those hold who conceive her similar to a
consimilem, cursusque uiam sub sole tenere.	ball and to have her course beneath the Sun. There
Est etiam quare proprio cum lumine possit	is also the possibility that she rotates with her own
uoluier, et uarias splendoris reddere formas.	light, producing different aspects of her splendour.
Corpus ENIM *licet esse aliud ~~quod~~ fertur, et una labitur,*	For another body may exist that moves and is gliding
omnimodis occursans officiensque,	with her, always running along and blocking her,
nec potis est cerni, quia cassum lumine fertur.	yet not discernible as being devoid of light.
Versarique potest, globus ut, si forte, pilai	It may also be that she rotate like a globe, if
dimidia ex parti candenti lumine tinctus,	perchance one half be painted in glistening light,
uersandoque globum uariantis edere formas,	and by rotating the globe she produce her aspects,
donique eam partem, quaecumque est ignibus aucta,	until she turns that part which is all filled with light
ad speciem uertit ***nobis*** *oculosque patentis;*	visible for our sight and our open eyes;
inde minutatim retro contorquet, et aufert	then by and by it turns to the back and increases
luciferam partem glomeraminis atque pilai;	the luminous part of the globe or ball.
ut Babylonica Chaldaeum doctrina refutans	This is what the Babylonian teaching of the
astrologorum artem contra conuincere tendit,	Chaldeans sets out, refuting the astronomers' art.
proinde quasi id fieri nequeat ~~quod~~ pugnat uterque,	Just as if what the two fight for could not coexist:
aut minus hoc illo sit cur amplectier ausis.	why should one more than the other be embraced?
DENIQUE *cur nequeat semper noua luna creari*	Moreover, why should not a new Moon be created
ordine formarum certo certisque figuris,	in a fixed order of aspects and in certain forms,
inque dies priuos aborisci quaeque creata	each of them every day created to perish, and
atque alia illius reparari in parte locoque,	to be replaced by another one in her place and stead?
difficilest ratione docere et uincere uerbis,	This is difficult to reason with or disprove in words,
ordine cum ‹uideas› tam certo multa creari.	as you see many things produced in a fixed order.

5 To qualify, a term must be used in a different way than in everyday Latin. Of course, there are uncertain cases.

Quite typically for his approach, the author is of the opinion that one should not try to evaluate the relative quality of different proposed scientific hypotheses (730), although he presents several of them.[6] By his time, there was no longer any doubt among Greek intellectuals that the first 'hypothesis' is the correct one. Technical vocabulary is rare, and all terms will have been understandable to the non-astronomer. In contrast, poetic figures such as synonyms are used (*glomeramen – pila – globus*), as well as hendiadys (*in parte locoque*); some rare poetic language is also used (*aborisco*, only here in CC; *donique* for *donec*). The syntax is not always clear (e.g. where does *super* in 709 belong?). All linguistic features highlighted in the text are very rare compared to the other samples.

(ii) Cicero, *De re publica* I.14(21–22), ed. Ziegler, pp. 14–15. The description of the Syracusan heavenly globe is presented. Before this passage, the observation of two suns was discussed.

Tum Philus: 'nihil novi vobis ***adferam****, neque quod a* ***me*** *sit ‹ex›cogitatum aut inventum;* NAM *memoria teneo C. Sulpicium Gallum, doctissimum ut scitis hominem, cum idem hoc visum diceretur et esset casu apud M. Marcellum,* ~~*qui*~~ *cum eo consul fuerat, sphaeram* ~~*quam*~~ *M. Marcelli avus captis Syracusis ex urbe locupletissima atque ornatissima sustulisset, cum aliud nihil ex tanta praeda domum* ***suam*** *deportavisset, iussisse proferri; cuius* ***ego*** *sphaerae cum persaepe propter Archimedi gloriam nomen audissem, speciem ipsam non* ***sum*** *tanto opere admiratus; erat* ENIM *illa venustior et nobilior in volgus,* ~~*quam*~~ *ab eodem Archimede factam posuerat in templo Virtutis Marcellus idem. sed posteaquam coepit rationem huius operis scientissime Gallus exponere, plus in illo Siculo ingenii quam videretur natura humana ferre potuisse iudicavi fuisse. dicebat* ENIM *Gallus sphaerae illius alterius solidae atque plenae vetus esse inventum, et eam a Thalete Milesio primum esse tornatam, post* AUTEM *ab Eudoxo Cnidio, discipulo ut ferebat Platonis, eandem illam astris* ~~*quae*~~ *caelo inhaererent, esse descriptam; cuius omnem ornatum et descriptionem sumptam ab Eudoxo multis annis post non astrologiae scientia sed poetica quadam facultate versibus Aratum extulisse. hoc* AUTEM *sphaerae genus, in quo solis et lunae motus inessent et earum quinque stellarum quae errantes et quasi vagae nominarentur, in illa sphaera solida non potuisse finiri, atque in eo*

Then Philus said: 'I shall not report to you anything new that was thought up or invented by myself. But I remember that when this same phenomenon [two suns] was reported, Gaius Sulpicius Gallus – as you know a very learned man – happened to be with M. Marcellus, who was consul with him; he ordered the sphere to be placed before him that Marcellus' grandfather had brought home from the wealthy and embellished town of the vanquished Syracusans, the only thing he had brought home from so much booty. I had often heard of this sphere because of the fame of Archimedes, but I did not so much admire its construction, for another one, which Marcellus had deposited in the temple of Virtue, also made by Archimedes, was in the general view more elegant and noble. But when Gallus began to explain the mechanism of this work in a very learned way, I judged that there was more ingenuity in that Sicilian than seemed possible in human nature. For Gallus said the other solid and full sphere was an old invention, first wrought by Thales of Miletus, then adorned by Eudoxus of Cnidus – as he said, a disciple of Plato – with the stars that are fixed in the sky. And that all its adornment and its description was taken from Eudoxus, was made public many years later in the verses of Aratus not with the knowledge of an astronomer but with a certain poetic agility. On this type of solid sphere, however, the Sun, the Moon and the five so-called wandering or rambling stars

6 An interesting point of contact between Epicureanism and postmodernism.

admirandum esse inventum Archimedi, ~~quod~~ excogitasset quem ad modum in dissimillimis motibus inaequabiles et varios cursus servaret una conversio. hanc sphaeram Gallus cum moveret, fiebat ut soli luna totidem conversionibus in aere illo quot diebus in ipso caelo succederet, ex ~~quo~~ et in [caelo] sphaera solis fieret eadem illa defectio et incideret luna tum in eam metam, ~~quae~~ esset umbra terrae, cum sol e regione ‹lacuna›.

could not be included; in this lay the admirable invention of Archimedes, who thought out, the movements being dissimilar, how a single revolution could produce the unequal and varied courses. When Gallus moved this sphere, it happened that the Moon followed the Sun with as many revolutions in that brass as it took the real sky days; by this the same eclipse of the Sun happened on the sphere and the Moon fell into the same point that marked the shadow of the Earth, when the Sun from the region […].

The work is a dialogue and therefore makes frequent use of the first person singular. There is hardly any technical vocabulary and hardly any Greek terminology, but the syntax is complicated and digressions are frequent (for instance here on the qualities of Aratus). The scientific details of how the sphere worked are not provided (probably not in the missing text either). The hendiadys *errantes et quasi vagae* is intended to render πλάνητες; later Latin will loan the word as *planetae* (as most modern languages do).[7] ESSE, REL, and modifiers are rather frequent, betraying Greek influence.

(iii) Pliny, *Naturalis historia* II.6(44–46), ed. Ernout et al., vol. 2, pp. 20–21. A passage on the movement of the Moon and its rôle in astronomical discoveries in the past.

Proxima ERGO *cardini, ideoque minimo ambitu, uicenis diebus septenisque et tertia diei parte peragit spatia eadem, ~~quae~~ Saturni sidus altissimum XXX, ut dictum, annis. Dein morata in coitu solis biduo, cum tardissime, a tricesima luce rursum ad easdem uices exit, haud* ***scio*** *an omnium, ~~quae~~ in caelo pernosci potuerunt, magistra: in XII mensium spatia oportere diuidi annum, quando ipsa totiens solem redeuntem ad principia consequitur: – solis fulgore reliqua siderum regi, siquidem in totum mutuata ab eo luce fulgere, qualem in repercussu aquae uolitare conspicimus: ideo molliore et inperfecta ui soluere tantum umorem atque etiam augere, quem solis radii absumant; ideo inaequali lumine adspici, quia, ex aduerso demum plena, reliquis diebus tantum ex se terris ostendat quantum a sole ipsa concipiat; in coitu* QUIDEM *non cerni,*

[The Moon] is closest to the cardinal point of the universe, thus it has the shortest orbit, in $27\frac{1}{3}$ days it traverses the same space that Saturn, the highest planet, does in thirty years, as has been said. Then after two days of conjunction with the Sun, on the thirtieth day at the latest she returns to the same place; she may well be the teacher of all heavenly phenomena that can be known:
– that it is proper to divide the year into the twelve spaces of months, when she reaches the Sun who has returned to the beginning [of his orbit] as many times,
– that the other stars are controlled by the Sun's splendour, shining forth in reflected light from him, which we see flutter as if reflected in water; thus, by the Moon's softer and imperfect force water can only be dissolved or augmented, whereas the Sun's rays consume it, thus she is seen in unequal light as she is full when opposite, the other days she shows the Earth only as much of herself as she receives from the Sun,

7 But note Icelandic *reikistjarna* ('roaming star').

quoniam haustum omnem lucis auersa illo regerat, unde acceperit; – sidera UERO *haud dubie umore terreno pasci, quia dimidio orbe numquam maculoso cernatur, scilicet nondum suppetente ad hauriendum ultra iusta ui; masculas* ENIM *non aliud esse quam terrae raptas cum umore sordes; – defectus* AUTEM ***suos** et solis, rem in tota contemplatione naturae maxime miram et ostento similem, magnitudinem umbraeque indices exsistere.*

but in conjunction she cannot be discerned as she turns back all collected light toward whence it came, – that the stars without doubt are nourished by earthly water, as when half full she is never seen spotted, that is, the force is not yet sufficient to draw more than its share: the spots are thus nothing else than dragged off earth with watery filth, – that her eclipses and those of the Sun are the greatest miracles in the observation of nature and similar to what is shown: pointers of the size and the shadow.

Paratactic infinitive clauses list pieces of information we have, apparently, learned thanks to the Moon.[8] The resulting syntax is not simple; the entire excerpt consists of only two sentences, but it looks carelessly composed, rather like a list; the logical nexuses between the idea that the Moon has taught us all we know about the heavens and the individual items seem to get lost toward the end. The technical details are wanting, but technical vocabulary is used consistently, though sparingly. The marked linguistic features are all relatively rare. Although this type of language is not rhetorical, it would not seem to be very technical either.

(iv) Martianus Capella, *De nuptiis Mercurii et Philologiae* VIII, §§862–864, ed. Willis, pp. 326–327. On the illumination of the Moon, thus the same topic as in the Lucretius sample. The scientific approach is now that of the Greek *communis opinio*.

Nunc iam Lunae meatum, quae terrae propinquior est, uideamus. Quam QUIDEM *menstruum habere lumen physicorum assertione persuasum est; cum ~~quod~~ sit, semper pleni orbis esse non dubium est.* N*AM* *si ab illa parte, ~~qua~~ se subicit Soli, omni hemisphaerio conlustratur, etiam cum **nobis** tricesima nullum lumen ostendit, superne, ~~qua~~ Solem spectat, pleno lumine relucescit; denique cum discedens a Sole a latere eum coeperit intueri, pro parte etiam inferius lumen adquirit, donec e regione posita ab hac parte, ~~qua~~ **nobis** est uisibilis, collustretur. Circuit* ENIM *eius globum undiquesecus Solis nitor et ei parti, ~~quam~~ totam tunc aspicit, lumen indulget, cuius luminis radii in terras quoque †lucubrandiore† perueniunt, ut si quis e speculo lumine repercusso effigiem lucis excipiat. ~~Quae~~* QUIDEM *Luna cum eum in orientis partibus comprehenderit, obscuratur, et cum in occasu*

Now let us take a look at the course of the Moon, which is closest to the Earth. Her monthly changing light was convincingly explained by natural enquiry. If it is so, there is no doubt that there is always a full circle. For on the part which faces the Sun a full hemisphere is illuminated, even when she shows us no light on the thirtieth day when she looks toward the Sun, she shines forth in full light above. Moreover, when she parts from the Sun she begins to look at him from the side, partly she receives light below until she gets positioned in the region in which she is visible to us, and is fully illuminated. The Sun's lustre then has moved around her globe and grants light to that full part that one can see, his rays then arrive on Earth also in more nightly shifts,[9] as when someone becomes aware of a form of light on a

8 Of these four 'observations', three are still believed today.

9 This would seem to be the meaning of this passage. Willis puts it in *cruces desperationis*.

deseruerit, lucescit. Cuius primi luminis effigies quibusdam uelut cornibus circulata μηνοειδής dicitur; cum UERO *XC partibus a Sole discedens orbem eius mediatenus idem radius luminarit, διχότομος perhibetur, sed praedictis partibus cum alias XLV adiecerit, ἀμφίκυρτος perhibetur, id est maior dimidia, minor plena; cum* UERO *CLXXX partibus a Sole discesserit, contrario posita totam partem, ~~quam~~ terris opponit, illuminans πανσέληνος perhibetur; ac dehinc deficiens seruat cum praedictis partibus nomina memorata. ~~Quae~~* QUIDEM *XIII orbis* ***sui*** *partes die nocteque transcurrit, cum pro latitudine circulorum, ~~quos~~ obeunt, eodem interstitio Mars dimidiam, Iuppiter duodecimam unius partis, Saturnus uicesimam octauam unius portionis excurrat.*

mirror reflecting light. One that, when the Moon apprehends it when he is still rising, is dim, but when met during his setting, shines forth. Her first likeness of light, pointy as if with horns, is called crescent-shaped [μηνοειδής], but when she recedes 90° from the Sun, half of her circle is illuminated, she is a half-moon [διχότομος], but when you add to the mentioned ones another 45°, she is gibbous [ἀμφίκυρτος], that is, more than half, less than full. But when she is 180° from the Sun, posited in opposition, the entire part facing toward the Earth illuminated, she is a full-moon [πανσέληνος]. From this she wanes, but the mentioned names are used again. She traverses 13° of her orbit in 24 hours, whereas due to the amplitude of the orbits they follow, in the same time Mars traverses 0.5°, Jupiter 0.08°, Saturn 0.036°.

A few Greek terms are used in the text, some unusual Latin ones (*lucubrandior, mediatenus*), complicated syntax, and a lot of sentence-modifying particles. All the marked features are relatively common, except suffixes. Martianus is fond of using poetical and metaphorical meanings of words ('the Moon is looked at by the Sun'); rhetorical *variatio* is common. It would seem that depending on his source, Martianus used technical terminology sometimes abundantly, sometimes hardly at all. He often intersperses his Latin with Greek words. It takes the reader a while to understand that the complicated sentence beginning with *Quae quidem Luna* presupposes the moment when the Moon rises over the horizon: if then the Sun is setting, the Moon is full and bright, if the Sun is still rising, the Moon is not yet full and less bright.[10] This is scientifically quite a trivial statement, wrapped in a very complicated, bombastic sentence. This approach is typical for Martianus, whose language looks more like an intricate and hermetic artwork for connoisseurs than matter-of-fact science.

(v) Albertus Magnus, *De caelo et mundo* I.1.11, ed. Hossfeld, vol. 5.1, p. 29. Albertus comments and explains Aristotle's cosmology in *De caelo;* quite typically, he often also analyses problems not directly mentioned in the Aristotelian text – in this case, whether the heavenly bodies can be said to suffer change.

10 Several printed translations misunderstand this point.

Est AUTEM *adhuc observandum, quod cum dicitur, quod caelum non alteratur, intelligitur de alteratione physica. Est* ENIM *quaedam alteratio* ~~*quae*~~ *non est motus, sed finis motus,* ~~*quae*~~ *fit subito per illuminationem et per lumen,* ~~*quod*~~ *est forma prima corporis luminosi, quia videmus bene,* ~~*quod*~~ *luna alteratur secundum hoc. Et* ***nos*** *etiam inferius* ***ostendemus****, quod omnis stella praeter solem sic alteratur, nec est instantia contra determinata, quod inveniuntur stellae frigidae et calidae et umidae et siccae, quia hoc dicitur de stellis per causam, quia talia efficiunt in inferioribus per naturam* ***sui*** *luminis,* ~~*quod*~~ *emittunt, et non disponuntur talibus qualitatibus. Et huius probatio est, quia, sicut nos in octavo physicorum probavimus, quod omnis motor secundum locum reduci et resolvi habet ad motorem primum,* ~~*qui*~~ *est immobilis secundum locum et simpliciter, ita necesse est, quod omne movens in alteratione reducatur ad unum alterans et non dispositum aliqua qualitate formaliter alterante; aliter* ENIM *primum factivum qualitatum alterantium esset factivum per accidens. Si* ENIM *diceretur, quod calor non sit nisi per motum et frigiditas per distantiam a motu, cum motus non faciat calorem nisi per accidens, non haberemus in natura substantiale et primum movens in alteratione, et hoc est inconveniens, quia secundum hoc primae qualitates,* ~~*quae*~~ *commiscent omnia et distinguunt elementa, essent per accidens et per consequens omnia* ~~*quae*~~ *fierent ex ipsis, essent per accidens et non per intentionem naturae.*

It is besides to be observed that when it is said that the heavens do not change,[11] this is understood in terms of physical alteration. For there is a kind of alteration that is not movement but the end of movement that happens immediately by illumination and by light which is the first form of a luminous body, as we see well that the Moon changes according to it. And we shall show below that every heavenly body except the Sun changes in this way; it is no objection against what is known: that some heavenly bodies are cold, some hot, some wet, some dry, because this is said of what the heavenly bodies cause, as they act among things down here by the nature of the light they emit, but they do not dispose of such qualities. And the proof of this is that, because as we have proven in the eighth book of the Physics[12] that every mover according to space has to be attributable and resolvable to the first mover, who is immobile according to space as well as absolutely, therefore it is necessary that everything that moves be attributed in alteration to something that alters it and that does not dispose of any formally altering quality, for otherwise the first agent of altering qualities altered by accident. For if it is said that heat exists only through motion and cold by the absence of motion, as motion produces heat only by accident, we would not have in nature a substantial and first mover in alteration, which is unsuitable, as according to this the first qualities which mix everything and distinguish the elements, would exist by accident and consequently everything that arises out of them would exist by accident and not by nature's intention.

The vocabulary is very technical, much more so than in the previous four samples. Logical nexuses are given much weight; they are unambiguous. Nominalised participles (*movens*, *alterans*) are used in a Greek way. Linking conjunctions are very common, especially the typically scholastic *quia* and *quod*, as well as the relative pronoun. In fact, all the marked features are common. Aristotelian vocabulary pervades the text. Potential subjunctives may also be noted as common in this passage.

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11 Cf. Aristotle, *De caelo* II.6, 288b33–289a1: Οὐθὲν δὲ τούτων δυνατὸν περὶ τὸν οὐρανὸν γενέσθαι· τὸ μὲν γὰρ κινούμενον δέδεικται ὅτι πρῶτον καὶ ἁπλοῦν καὶ ἀγένητον καὶ ἄφθαρτον καὶ ὅλως ἀμετάβλητον ('Nothing of these things may happen to the sky. It has been shown that what is moved is primary, simple, uncreated, imperishable, and generally unchangeable').

12 Cf. *De physica* VIII.2.9, ed. Borgnet, vol. 3, pp. 588b–589a.

(vi) Newton, *Principia mathematica* III, prop. V. theor. V. (Londini, 1687 edition, p. 407). About the Jupiter moons.

Planetas circumioviales gravitare in Iovem, & circumsolares in Solem, & vi gravitatis ***suae*** *retrahi semper a motibus rectilineis, & in orbibus curvilineis retineri.*
Nam revolutiones Planetarum circumiovialium circa Iovem, & Mercurii ac Veneris reliquorumque circumsolarium circa Solem sunt Phaenomena eiusdem generis cum revolutione Lunae circa Terram; & propterea per Hypoth. II. a causis eiusdem generis dependent: praesertim cum demonstratum sit quod vires, a ~~quibus~~ revolutiones illae dependent, respiciant centra Iovis ac Solis, & recedendo a Iove & Sole decrescant eadem ratione ac lege, ~~qua~~ vis gravitatis decrescit in recessu a Terra.
Corol. 1. Igitur gravitas datur in Planetas universos. Nam Venerem, Mercurium caeterosque esse corpora eiusdem generis cum Iove nemo dubitat. Certe Planeta Hugenianus, eodem argumento ~~quo~~ Satellites Iovis gravitant in Iovem, gravis est in Saturnum. Et cum attractio omnis (per motus legem tertiam) mutua sit, Saturnus vicissim gravitabit in Planetam Hugenianum. Eodem argumento Iupiter in Satellites ***suos*** *omnes, Terraque in Lunam, & Sol in Planetas omnes primarios gravitabit.*
Corol. 2. Gravitatem, quae Planetam unumquemque respicit, esse reciproce ut quadratum distantiae locorum ab ipsius centro.

That the Jupiter moons gravitate around Jupiter, the planets around the Sun, and that they are drawn off continuously from rectilinear motion by their gravitational force and retained in curvilinear orbits.
For the revolutions of the Jupiter moons around Jupiter and those of Mercury, Venus, and the other planets around the Sun are phenomena of the same kind as that of the Moon around the Earth, and therefore according to hypothesis II[13] depend on causes of the same genus, especially as it was shown that the forces on which the revolutions depend, tend to the centres of Jupiter or the Sun, and that they decrease in the same ratio and according to the same law receding from Jupiter or the Sun as the gravitational force decreases when receding from the Earth.
Corollary 1. Therefore, gravity acts on all planets, for no one doubts that Mercury, Venus, and the others are bodies of the same kind as Jupiter. Certainly, Huygens's planet [Titan] gravitates on Saturn by the same argument as the Jupiter satellites do on Jupiter. And as every attraction is mutual (by the third law of motion),[14] Saturn also gravitates toward Huygens's planet. By the same argument, Jupiter will gravitate toward all its moons, the Earth toward the Moon, and the Sun toward all primary planets.
Corollary 2. The gravity that concerns any planet is to the inverse square of the distance of the places from its centre.

The theorem is stated as an independent *accusativus cum infinitivo*; it is then proved from what had been said before. The language is full of technical terms, often (though not here) including mathematical formulas, proofs, geometric diagrams. There are many Latin true compounds (*circumiovialis, circumsolaris, curvilineus, rectilineus*) in this passage, although this may not be very typical in general. The recently discovered Saturn moon Titan is called *planeta Hugenianus* after its discoverer, Christiaan Huygens. Syntactically the text is concise and clear but not conspicuous; the other highlighted features are common.

13 At the beginning of book III (p. 402), hypothesis II was stated as: *Ideoque effectuum naturalium eiusdem generis eaedem sunt causae* ('Therefore the causes of natural effects of the same kind are the same').
14 Treated in I, prop. III, theor. III, p. 39.

(vii) Vossius, *Ars historica* 6 (Lugduni, 1653 edition, pp. 32–33). On the invention of historiography and the Arcadians, who are said to be older than the Moon.

Longè VERÒ *alia ratio historiae est. ~~Cujus~~ inventrix Clio dicitur Apollonii scholiastae*[1] *in librum III. Λέγεται τῶν Μουσῶν ἡ μὲν Κλειὼ εὑρηκέναι τὴν ἱστορίαν. Clio, Musarum una, historiam invaenisse fertur. Inventionem Cadmo Milesio tribuit Plinius lib. VII. cap. LVI. ~~quo~~ etiam loco Pherecydem Syrium scribit primùm prosam condidisse. At lib. V cap. XXIX id ipsum etiam Cadmo tribuit, alios, puto, secutus autores. Sed et Strabo lib. I tradit, Hecataeum cum Cadmo et Pherecyde metrum solvisse, ac primos prorsam instituisse orationem, eâque de re adeunda quoque Suidae collectanea.* ***Nos*** *apud Graecos hos fuisse historiae autores, haut inficias imus: at ἁπλῶς si intelligant, Mosen longè antiquiorem historicum agnoscimus. Quin & eum historiae conditorem putat Eusebius lib. XI. de praepar. Euang. Atque, ut id non esset, Aegyptiis potiùs haec laus deberetur, quàm Graecis: ~~quos~~ ita compellat Tatianus initio orationis* ***suae:*** *Ἱστορίας συντάττειν αἱ παρ' Αἰγυπτίοις τῶν χρόνων ἀναγραφαὶ ἐδίδαξαν.*[2] *Aegyptiorum* CERTE, *Chaldaeorumque sacerdotes diu ante Graecos antiquitatis fuerunt studiosi. quamquam quod jactitant se conscriptas habuisse historias multorum annorum millium, id non magis verum est, quàm quod Arcades (ut scribit Statius Papinius) fuerint astris Lunâque priores, uti gloriabantur; προσελήνων nomen à populis finitimis inditum, quòd nihil serii ante novilunium aut plenilunium aggrederentur, interpretatione* ***sua*** *eludentes, atque ad gentis originem referentes: nisi malis cum Censorino,*[3] *id nomen accepisse, quòd priùs* habuerint annum, quàm is in Graeciâ ad Lunae cursum constitueretur.

There is indeed a very different foundation of history. Its inventor is said to be Clio, according to Apollonius' scholiast in book III:[15] Λέγεται τῶν Μουσῶν ἡ μὲν Κλειὼ εὑρηκέναι τὴν ἱστορίαν. 'Of the Muses, Clio is said to have discovered history'. Pliny in book VII, chapter 56[16] attributed the discovery to the Milesian Cadmus, where he also writes that Pherecydes the Syrian first established prose writing. But he attributes this same feat also to Cadmus in book V, chapter 29, following, I think, other sources. But also Strabo passes on that Hecataeus together with Cadmus and Pherecydes overcame metre and established prose writing; about this very matter the Suda collection has to be consulted. We do not disown that these were the founders of historiography among the Greeks, but if understood simply, we acknowledge Moses to have been a much earlier historian. Indeed Eusebius, *De praeparatione evangelica* book IX, holds him to be the founder of history. And, if this were not so, this glory rather belonged to the Egyptians than to the Greeks, whom Tatian[17] addresses at the beginning of his oration as: Ἱστορίας συντάττειν αἱ παρ' Αἰγυπτίοις τῶν χρόνων ἀναγραφαὶ ἐδίδαξαν. The priests of the Egyptians and the Babylonians were certainly students of Antiquity long before the Greeks, although their proclamation of having written the history of many thousand years is not more true than that the Arcadians were (as Statius Papinius writes) 'older than the stars and the Moon',[18] as they prided themselves. They were given the name 'before the Moon' by their neighbouring peoples, because they undertook nothing serious before a new moon or a full moon, they parried this with their own interpretation linking the name to their people's origin; unless you prefer with Censorinus to derive this name 'from the fact that they had a year constituted by the Moon's course before that of Greece'.

15 Cf. *Scholia in Apollonii Rhodii Argonautica*, ed. Wendel, p. 215: 'it is said that of the Muses Clio invented history.'
16 *Naturalis historia* VII.56(118), ed. Ernout et al., vol. 7, p. 205.
17 *Oratio ad Graecos* I.1, ed. Goodspeed, p. 268: 'the writing down of temporal events by the Egyptians taught [you Greeks] the composition of history books.'
18 Cf. Statius, *Thebais* IV.275, ed. Klotz & Klinnert, p. 128.

Notae:	*Footnotes:*
[1] *pag. 197.*	[1] Page 197.
[2] *Historiam scribere Aegyptiorum annales docuerunt.*	[2] Writings of the Egyptians taught the composition of history.
[3] *De die natali, cap. 19.*	[3] *De die natali* 19.

This text looks like a modern text of the human sciences, complete with footnotes and references; the sources are quite precisely quoted. The quality of sources is evaluated in a similar manner to scholasticism, but the resulting text is much less strictly and uniformly structured. The vocabulary is not very technical, but it usually quotes Greek without translation. Subordination is common, but the relative pronoun is not, and the other marked features are also not very plentiful – quite in contrast to the passage from Newton. On the whole, this is a pragmatic and clear form of academic Latin, except for some very rhetorical interspersed passages.

Table 15: Pertinent values for these texts, copied from tables 11, 13, and 17.

	ESSE	REL	CONJ:S	PRON: POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy	Word length
Lucretius	2.55	3.27	3.09	0.53	2.13	7.67	0.73	0.60	1.38	4.61	9.66	5.58
Cicero	4.73	4.81	3.30	0.58	4.88	10.04	1.27	2.77	2.78	2.34	9.09	5.69
Pliny	2.12	2.49	1.71	0.31	1.23	13.56	1.93	2.26	0.84	7.81	10.38	6.04
Martianus	5.49	3.71	2.54	0.23	1.54	16.99	0.41	1.84	2.56	1.59	9.84	5.64
Albertus	6.74	5.09	2.41	0.35	0.46	16.84	3.05	4.86	2.73	0.75	8.19	5.95
Newton	3.91	2.61	3.85	0.39	2.97	16.51	2.29	4.78	1.26	3.26	8.57	5.84
Vossius	3.45	4.30	2.89	0.65	3.11	8.80	1.84	3.75	1.52	1.86	9.26	6.08

§5 The numerical values pertinent here are repeated in a single table for these seven typical authors (table 15).[19] It is interesting to note that Cicero, Martianus, and Albertus share a predilection for ESSE, REL, and modifiers, although one might be tempted to see these three authors as representing the most incommensurable Latin scientific style ideals. On the other hand, suffixation may be a better indicator of technical Latin: Pliny, Albertus, Newton, and Vossius have high numbers. Low numbers for possessive pronouns and (to a lesser degree) the first person sin-

19 In the case of Albertus, another work was used as *De caelo* is not available digitally; for Martianus, data from another book (on arithmetic, presented in the next chapter) were used.

gular seem to be typical for all of these scientific types of Latin, as do high numbers for the third person passive, except in scientific poetry, which certainly differs most conspicuously from the rest. Low, or at least not high, entropy values may also be typical of technical scientific writing.

When reading these texts, it becomes obvious how greatly the language of science used before and after the twelfth century differs both in content and in form. Before, practically exclusively popular and practical science is found in Latin; in contrast, the three later registers ('scholastic', 'mathematical', 'modern academic') are vehicles for theoretical science written by specialists for specialists. These types of scientific Latin are rather general. The results could probably be refined by including samples from specific sciences; historiography and medicine, in particular, would be interesting. Some forays along these lines are attempted in the next chapter.

20 Specific corpora: Arithmetic, historiography, scientific poetry

> The work of mathematicians of the third and the second centuries B.C. is perhaps the greatest – certainly it was the most permanent – achievement of Greek science.
>
> Lloyd (1973: 51)

§1 The data on the general corpus in the previous two chapters made it possible to demonstrate some differences between scientific Latin and other types of Latin, and it made it possible to differentiate between several different scientific styles. But, of course, the texts in that corpus are of a rather heterogeneous nature. For this reason, here some smaller corpora with texts from a single field but from different times are studied using similar methods, namely two scientific disciplines (arithmetic and historiography) and one genre (scientific poetry). Finding a scientific topic that is studied seriously and continuously across the two thousand years in Latin is surprisingly difficult: interests shifted, and some fields were abandoned or felt to be complete and not worthy of further study, while others were newly invented or rediscovered. A relatively easily definable and uncontroversial field with many theoretical contributions written in Latin is arithmetic. According to Dasypodius, *Λέξικον*, p. 1r, it is defined thus:

> *Arithmetica es scientia, quae uim et naturam numerorum tradit: adfectiones etiam et accidentia per se eorundem explicat.*
> ‘Arithmetic is the science that studies the force and nature of numbers: it also explains relations and what happens between numbers.’

Table 16 shows the seventeen works on arithmetic used; they all treat numbers scientifically and are more than mere introductory compendia: thus, practical *algorismi* or *Rechenbücher,* commercial textbooks (*De abaco*), and the related field of *computus* were excluded.[1] Commentaries were also excluded, as this genre is likely to behave in its own way, although there can be no doubt that it was important in the development of Latin arithmetic. Often, new insight was developed in the form of commentaries on older works, for instance in the case of Iacobus Faber Stapulensis’ (ca. 1455–1536) commentary, *Arithmetica decem*, on Iordanus de Nemore’s three-centuries-older treatise. In passing, it should also be mentioned that mathematics is a science in which on the one hand the vernacular was used

1 These criteria are not treated too rigidly before the twelfth century: if they were, we would be left with no Latin works at all.

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early on by Italian writers – such as Luca Paccioli (ca. 1447–1517), Niccolò Tartaglia (1499/1500–1557), or Rafael Bombelli (1526–1572) – but on the other hand important contributions were often written in Latin up to the nineteenth century (see chap. 14 §2). Of course, only Latin works are used in this chapter.

The topics relevant to the study of numbers changed over the centuries, as did the field's relation to geometry and algebra. Books VII–IX of Euclid's *Elementa* treat arithmetic in a geometric way and provided the foundation for practically all that followed in Latin arithmetic. While later on, arithmetic developed into its own independent field, for instance in Archimedes' *Psammites*, non-rational real numbers (such as π) were usually still dealt with in a geometric fashion, as there was no way of writing them as numbers. With the advent of differential calculus (Leibniz and Newton) the borders between arithmetic and geometry became even more blurred. Although there did exist Latin books on arithmetic before Boethius, they are unfortunately lost to us. For instance, we know that Varro's *Disciplinae* treated the *artes liberales*,[2] and moreover that Apuleius wrote on mathematics as well. As the least explored times in Latin's development are after Antiquity, it may not be too inappropriate to begin this corpus as late as Martianus and Boethius and to focus more on the later phases of the language.

§2 As many of these texts are of a rather specialist nature, little known to the general reader, their content and importance is at least summarised very briefly, illustrating some of the major themes that were under discussion during these different times. The texts can be read online in Corpus Corporum. General histories of mathematics paying at least some attention to historical and philological details are very rare. The usual approach is still that of a broad history of ideas, especially of ideas that were to last until today: to show how what we do today originated, at best mentioning some dead ends trodden in the past.[3] For the important time of 1500 to 1740, the monumental Latin-language work by Johann Christoph Heilbronner, *Historia matheseos* (Lipsiae, 1742), can still be useful.[4]

Arithmetic, as the scientific study of numbers and their properties, was developed by the Greeks hand-in-hand with numerology (the mystical properties of

2 Probably including *arithmetica*. See von Albrecht (1992–1994: 2:1243).

3 Smith (1923–1925) is still good reading, as well as Cantor (1880: 703–782), treating the Latin Middle Ages. For early prints of arithmetic texts, see Smith (1908). Gowers, Barrow-Green & Leader (2008b) does contain lives of important mathematicians, but very few from before the seventeenth century.

4 On pp. 779–842, he lists authors on arithmetic in this timeframe. This book's other most lasting contribution may be the author's search for mathematical knowledge in the works of Aristotle (pp. 172–273).

numbers). As already mentioned, the roots of the field can be seen in Euclid, who collected what was known in his day and whose work was so successful that it supplanted almost everything else, which is now lost for us. After Euclid, in the third and second centuries, there were great advances in the mathematical disciplines, achieved by men such as Archimedes, Eratosthenes, and Apollonius of Perga, which are, however, for the most part not well preserved. Rediscoveries of some of their works in the Renaissance were to change some sciences significantly. Instead of these highly technical, advanced works, the handbook by Nicomachos of Gerasa (fl. ca. AD 100), who was more interested in the philosophy of numbers than in strict proofs, was to become the foundation of later developments. Some later Greek authors such as Diophantus (third century AD) and Pappus (d. ca. AD 350) would, again, become important for the further development of the field when they were finally translated into Latin.

The earliest surviving Latin text on arithmetic is §§743–801 of book VII of Martianus Capella's *De nuptiis*.[5] Based on Euclid and Nicomachus, it explains the basics of number theory. The book was widely read in the Middle Ages. Boethius' *De arithmetica* is also based on Nicomachus' book; indeed, it is largely a translation of it. The treatment of this topic in Isidore's encyclopaedia is, again, based largely on Boethius and Cassiodorus (*Institutiones* II.4, too short to be included in the sample), and thus indirectly on Nicomachus. On the whole, it may be said that Latin Antiquity did not seem to add new knowledge to Euclid and Nicomachus. The same is largely true up to the twelfth century;[6] Ps-Bede is rather a compilation for school use, possibly consisting of two parts that did not originally belong together.[7] In the twelfth century, things change, as Euclid's *Elementa* is translated (see chap. 21 §2 below) and is now directly accessible in full. The first surviving translation, by an anonymous Sicilian, is included in the sample (only the books treating arithmetic: VII–X). At roughly the same time, Arabic mathematics becomes available in Latin. Two texts about whose genesis and authorship very little is known are used (*Anxiomata*, *Regule*), except that they may have been written among the entourage of Adelard of Bath.[8] Through the Arabs, Indian decimal numbers are introduced to Europe, greatly facilitating the handling of numbers in

5 The rest of book VII contains numerology and its literary framework. On author and work, see chap. 9 §5 above.

6 As stressed above (chap. 9 §1): the Roman and early mediaeval periods can be seen as one period in the study of science in Latin.

7 Jones (1939: 48). This Ps-Bede text of practical character is edited by Folkerts (1972), who dates it to around 820. On Latin arithmetic before the translations, see Folkerts (2001).

8 Edited in Burnett (1996), besides Allard (1997: 212).

arithmetic.[9] Iordanus de Nemore's work in the thirteenth century is a first summarising reworking of the new knowledge and would be very successful for a long time. Iohannes de Muris is, again, largely based on Boethius and was used as a relatively elementary schoolbook. The two works from the fourteenth century (Albert of Saxony and Nicolaus Oresmius) use arithmetic for physical problems, but both do so at a very theoretical level and can be seen as precursors of mechanics in the Scientific Revolution. The Austrian astronomer Iohannes de Gamundia (of Gmunden) treats arcs and angles numerically in his *De sinubus et chordis*. Franciscus Maurolycus, an Italian with Greek roots, was also a student of Greek texts and learned from Diophantus;[10] his work on arithmetic was meant to go beyond Euclid, Nicomachus, and Iordanus (I, prol., 1575 edition, p. 1). With Franciscus Vieta (and John Wallis), a new interest in the infinite becomes apparent, culminating in Leibniz's and Newton's calculus. The text by Leibniz is one of the foundational works of infinitesimal calculus.[11] This is the first work that looks like a contemporary mathematics paper. It is full of formulas and very much to the point. The author does not care about rhetorical language at all; he makes up unusual words such as *infinitangulum* ('apeirogon'; 470) without any apologies. Leonard Euler's short study also follows these lines,[12] whereas Gauß's work combines number theory and algebra, reworking much of the advances of the past century and introducing much novelty of his own. The book is a classic in the field. It also reads like a modern mathematics textbook. Gauß's works are among the last fundamentally important works in the field first published in Latin.[13]

Unfortunately, few of these rather technical texts were available in digital form. Were it not for Busard's tireless editing, few of the mediaeval ones would even be available in printed editions. Since I had to digitise many of the texts in this corpus myself, the texts used tend to be relatively short excerpts, which may render the results less certain.

§3 Comparative tables provide basic information about the authors, works, and editions (table 16–17) used in this chapter. For the post-classical vocabulary (as for the general corpus above), the 1,000 words after the first 1,000 words were

9 Ambrosetti (2008: esp. chap. 10) studies the Arabic influence in late mediaeval and early modern mathematics.

10 His many works are currently being edited at the University of Pisa.

11 On its development, see Spalt (2015).

12 His works can be found online at http://eulerarchive.maa.org/index.html.

13 Especially his *Disquisitiones generales circa superficies curvas* (Göttingen: typis Dieterichianis, 1828); there are some later important but short works, such as Giuseppe Peano's *Arithmetices principia* (Turin: Bocca, 1889; https://archive.org/details/arithmeticespri00peangoog).

studied and compared to surviving literature before AD 200 as contained in Corpus Corporum. The lists are printed in appendix 2. Somewhat surprisingly, the mediaeval authors hardly use non-classical words, whereas the late antique and the early modern ones do so profusely, especially Martianus Capella, Maurolycus, and Leibniz. The arithmetic texts contain in total 166 [574] such lemmata [occurrences]. They include 92 [381] ADJ, 3 [6] ADV, 56 [148] N, 12 [17] V, and 3 [22] PRON. Here, ADJ are more common than N. The structure of the works is strongly influenced by Euclid as soon as his text becomes available. Early modern authors tend to follow the same structure still in use today: definitions are followed by propositions and their proofs. The use of formulas also becomes more common with time.

Table 16: The seventeen arithmetic texts used in this corpus.

Author and work[14]	Life dates or date of publication	Topic of the work	No. of words,[15] avg word length	Post-classical words, types/ tokens[16]	Brief description of style	Knew Greek?	Diagrams, formulas, graphics, proofs?
Martianus Capella, *Du nuptiis* VII, ed. Willis (1983)	5th century	introduction based on Nicomachus	10 5.64	17 43	discursive	Y?	N
Boethius, *De arithmetica* PL 63 (1863)	ca. 480–524	introduction based on Nicomachus	30 6.31	9 12	discursive with *conclusiones* and *probatur*	Y	N
Isidore, *Etymologiae* III.2–9, ed. Lindsay (1911)	ca. 560–636	introduction based on Nicomachus	2 6.05	18 47	discursive	N	N
Ps-Bede, *De arithmeticis propositionibus* PL 90 (1904)	ca. 820	schoolbook	5 6.05	5 8	discursive	N	N
Anxiomata artis arithmeticae, ed. Burnett (1996)	mid-12th century	definitions and basic rules	2 4.93	15 43	exercises	N	N
Anonymus Toletanus, *Regule*, ed. Burnett (2010)	ca. 1170	basic rules and questions	10 5.95	4 13	discursive	N	D

14 Red means less than the average minus 1 stdev, green more than the average plus 1 stdev.
15 In thousands. The shortest texts are around 2,200 words; most are much longer. The average word length for these texts is 5.97 ±0.52, almost identical to the benchmark: 5.95 ±0.32.
16 The average numbers for these texts are 12.2 ±6.9 and 33.4 ±24.3. The numbers are not comparable to those in chap. 18 as a smaller sample was used to obtain them.

Table 16: (continued)

Anonymus Siculus, *Elementa* translation (books VII–X), ed. Busard (1987)	ca. 1175	translation of Euclid	41 4.80	2 16	*definitiones, propositiones,* proofs (geometric)	Y	D P
Iordanus de Nemore, *De elementis arithmetice artis,* ed. Busard (1991)	fl. ca. 1230	compendium including proofs	45 6.14	2 6	*definitiones, propositiones,* proofs (geometric)	N?	P
Iohannes de Muris, *Arithmetica speculativa,* ed. Busard (1971)	1343	problems, often about proportions	7 6.25	9 27	discursive with definitions	N?	D F
Albert of Saxony, *De proportionum*, ed. Busard (1971)	ca. 1320–1390	proportions and their use in physics	7 6.11	17 86	discursive with *conclusiones* and *probatur*	N?	P
Nicolaus Oresmius, *De proportionibus proportionum,* ed. Grant (1966)	ca. 1320–1382	proportions and their use in physics	20 5.82	15 39	discursive with *conclusiones* and *probatur*	N?	P F
Iohannes de Gamundia, *De sinibus et chordis,* ed. Busard (1971)	1437	trigonometry	18 5.76	7 23	discursive with proofs	Y?	D F
Franciscus Maurolycus, *Arithmeticorum libri duo,* ed. Pasquotto (2017)	1575	number theory	27 6.78	26 91	*definitiones, propositiones,* proofs	Y	P F
Franciscus Vieta, *In artem analyticem isagoge* (Lugduni Batavorum, 1646)	1591	analytic geometry	5 6.60	11 29	discursive with proofs	Y	P F
Gottfried Wilhelm Leibniz, *Nova methodus pro maximis et minimis* (Lipsiae, 1684)	1684	calculus	2 5.72	21 37	*definitiones, propositiones,* proofs	Y	P F
Leonhard Euler, *Introductio in analysin infinitorum* (Petropolis, 1740)	1748	calculus	3 6.23	12 19	*definitiones, propositiones,* proofs	Y	P F
Carl Friedrich Gauß, *Disquisitiones arithmeticae* (sections 1–2) (Leipzig, 1801)	1801	systematic algebra and arithmetic	8 6.41	17 28	*definitiones, propositiones,* proofs	Y	P F

Table 17: Showing the same values as above for the general corpus (see table 13). Again, the first four values, the 1st person singular, and the 3rd person passive are given as percentages of V, the cases as percentages of N only (the rare cases VOC and LOC are not included). All other values are simple percentages, except ABL ABS, which is given in occurrences per 1,000 words. Colours are used as in table 12. Entropy values with * are not included as the texts are too short to produce trustworthy numbers; the average was calculated without them.

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-ADJ	Modifiers	ABL ABS	Entropy
Martianus	64.92	13.27	7.10	13.39	29.88	19.37	24.37	26.38	5.57	3.76	2.58	0.23	1.56	17.14	0.42	1.87	2.56	1.62	*
Boethius	59.85	15.17	5.44	17.59	29.97	17.04	23.68	29.31	5.54	3.66	3.32	0.28	1.47	17.30	1.70	7.00	3.98	4.11	8.14
Isidore	62.10	12.96	6.11	17.85	30.13	17.33	22.93	29.60	5.65	3.77	3.72	0.81	1.71	15.40	1.61	2.33	1.84	0.90	*
Ps-Bede	50.40	18.54	6.25	15.97	24.12	12.33	35.91	27.63	4.32	3.72	2.57	0.50	2.21	6.48	0.48	2.99	1.65	1.92	*
Anxiomata	56.92	10.26	2.82	17.44	33.23	12.26	34.19	20.32	4.96	2.48	4.23	0.34	0.77	14.87	1.46	3.40	1.22	0.97	*
Anonymus Toletanus, *Regule*	50.35	15.35	5.41	19.31	30.01	19.20	29.24	21.55	4.83	3.57	3.06	0.31	0.57	10.25	1.43	3.98	2.08	1.80	7.52
Anonymus Siculus	63.38	13.27	3.85	17.16	36.05	15.09	30.11	18.76	5.79	3.60	2.88	0.01	3.61	19.46	2.32	3.89	6.68	0.67	6.22
Iordanes de Nemore	46.99	27.00	5.99	17.25	38.42	11.84	26.69	23.05	7.26	3.43	4.12	0.16	1.00	13.04	1.55	3.65	2.19	1.28	7.04
Iohannes de Muris	64.80	12.22	4.71	12.76	37.40	17.34	15.92	29.33	6.19	3.07	3.23	0.15	0.18	17.10	1.95	3.04	1.74	2.92	*
Albert of Saxony	55.17	15.77	5.05	19.81	31.84	12.43	26.72	29.01	4.52	3.57	2.89	0.64	2.64	18.26	1.94	4.59	1.36	1.33	*
Oresmius	55.73	19.11	7.87	13.30	41.22	16.17	21.27	21.33	8.07	3.24	3.97	0.12	3.91	12.69	3.42	8.70	1.83	1.59	7.16

Table 17: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-ADJ	Modifiers	ABL ABS	Entropy
Iohannes de Gamundia	47.32	6.96	3.00	31.69	31.73	22.62	29.18	16.46	6.61	3.91	2.02	0.06	1.32	5.16	2.62	3.02	1.85	1.62	7.10
Maurolycus	48.40	11.83	2.54	33.24	31.68	21.81	21.39	25.11	4.87	3.36	1.86	0.24	3.33	9.04	3.16	5.47	1.76	3.25	7.64
Vieta	41.83	11.17	9.69	30.14	24.67	11.51	26.52	37.31	4.27	3.10	2.86	0.52	1.48	14.33	2.93	9.22	1.24	4.05	*
Leibniz	36.77	17.56	11.71	29.74	27.84	15.46	24.40	32.30	5.59	2.50	3.69	0.60	1.41	10.30	4.67	4.67	1.57	3.26	*
Euler	39.61	25.35	9.70	22.58	34.79	13.35	28.88	22.98	4.94	3.81	4.10	0.15	3.74	16.48	0.98	5.08	3.16	1.45	*
Gauss	44.68	18.18	16.72	16.72	38.40	16.23	27.10	18.27	5.41	2.68	3.14	0.19	0.92	13.64	1.30	5.24	1.13	2.50	*
avg arithmetic	**52.31**	**15.53**	**6.70**	**20.35**	**32.43**	**15.96**	**26.38**	**25.22**	**5.55**	**3.37**	**3.19**	**0.31**	**1.87**	**13.58**	**2.00**	**4.60**	**2.23**	**2.07**	**7.26**
stdev	*8.94*	*5.14*	*3.62*	*6.69*	*4.80*	*3.44*	*4.85*	*5.59*	*1.03*	*0.46*	*0.71*	*0.23*	*1.17*	*4.14*	*1.10*	*2.07*	*1.36*	*1.08*	*0.60*
avg 'science' (chap. 18)	**51.43**	**13.29**	**12.40**	**18.41**	**27.96**	**17.82**	**25.80**	**28.43**	**4.75**	**3.94**	**3.00**	**0.58**	**2.46**	**12.75**	**1.98**	**4.66**	**1.85**	**2.68**	**8.84**
Poetry corpus	49.57	11.06	10.78	23.06	25.31	11.30	32.92	30.48	1.99	2.23	1.78	1.54	5.23	4.57	1.35	0.87	0.61	5.49	9.92
avg benchmark (chap. 18)	**49.31**	**14.31**	**12.42**	**18.64**	**23.71**	**18.38**	**28.45**	**29.46**	**3.72**	**3.53**	**2.92**	**1.56**	**4.44**	**9.14**	**1.25**	**4.19**	**1.46**	**3.03**	**9.15**
stdev	*3.19*	*1.75*	*2.17*	*1.71*	*1.10*	*1.75*	*1.14*	*1.97*	*0.26*	*0.53*	*0.21*	*0.35*	*1.94*	*0.97*	*0.18*	*0.51*	*0.28*	*0.41*	*0.20*

Table 18: PoS values for the arithmetic corpus as percentages. Compare the values in table 12 from the general corpus.

	ADJ	ADV	CONJ	N	PREP	PRON	V
Martianus	23.31	8.21	10.76	16.03	8.61	13.69	19.38
Boethius	20.69	9.93	10.55	19.65	8.84	10.35	19.99
Isidore	22.65	8.12	10.87	17.33	9.54	12.75	18.75
Ps-Bede	14.53	7.25	9.07	22.78	9.76	10.05	26.57
Anxiomata	21.43	7.93	12.22	17.29	9.31	12.61	19.21
Anonymus Toletanus, *Regule*	18.82	8.32	11.28	18.24	10.66	11.07	21.62
Anonymus Siculus	14.99	14.20	9.63	20.17	15.76	9.78	15.48
Iordanes de Nemore	19.78	7.97	12.87	10.34	17.85	10.96	20.22
Iohannes de Muris	18.94	11.49	12.95	15.17	12.61	10.85	17.98
Albert of Saxony	20.66	10.30	10.35	13.91	14.31	10.94	19.53
Oresmius	20.70	8.24	12.86	17.10	11.68	10.63	18.79
Iohannes de Gamundia	17.36	5.96	9.66	24.45	11.97	9.54	21.06
Maurolycus	20.47	9.05	7.96	19.63	13.62	10.75	18.53
Vieta	16.52	6.67	8.68	23.60	13.36	8.42	22.76
Leibniz	16.48	8.41	14.16	16.42	9.42	11.00	24.10
Euler	11.75	9.95	9.65	17.47	12.55	11.10	27.54
Gauss	17.01	8.55	10.50	19.25	12.05	12.27	20.37
avg arithmetic	**18.59**	**8.86**	**10.82**	**18.17**	**11.88**	**10.99**	**20.70**
stdev	*3.10*	*1.92*	*1.71*	*3.52*	*2.58*	*1.28*	*3.07*
avg 'science' (chap. 18)	**12.36**	**9.74**	**9.86**	**24.49**	**9.13**	**12.55**	**21.87**
Poetry corpus (chap. 18)	15.52	7.23	7.28	30.54	4.38	10.49	24.57
avg benchmark (chap. 18)	**10.06**	**8.95**	**9.93**	**25.69**	**8.30**	**14.13**	**22.93**
stdev	*0.87*	*0.53*	*0.43*	*1.40*	*0.77*	*1.12*	*1.03*

The same parameters and the same methodology were used as in the previous chapter, with the exception of the entropy measurement. As argued there, for texts shorter than 10,000 words such a measurement would not make sense, and many of the texts in this corpus are shorter. For the texts that are longer than 10,000 words, the entropy is 7.26 ±0.60, thus significantly lower than in the other samples above. This indicates a linguistic monotony in these texts.

§4 The numbers show immediately that arithmetical Latin differs greatly from other prose, but within these texts less clear-cut subgroups are found. The benchmark texts are still expected to remain close together in PCA plots, and the metrical samples are expected to be furthest removed from this corpus's texts. Among the arithmetic texts, one might expect a grouping of pre-twelfth-century, scholastic-era, and Scientific-Revolution-era texts. First observations from the data in the tables show many characteristics that these texts together share with the general scientific sample, such as

- much higher (at least 3 stdevs) than usual: ADJ,[17] PREP, NOM, ESSE, 3rd PAS, ADJ-SUF, modifiers;
- higher (at least 1 stdev) than usual: CONJ, ADJ-SUF;
- lower (at least 1 stdev) than usual: PRON, INF, GEN, ACC, ABL/DAT, 1st SG, ABL ABS;
- much lower than usual (at least 3 stdevs): N, PRON:POSS, entropy.

The following values contrast strongly with the general sample used in chapter 18: ADJ, PREP (more common); N, INF, entropy (lower). Among the arithmetic authors, post-Scientific-Revolution authors (Vieta, Leibniz, Euler, Gauß) use INF more normally, and early modern authors (Gamundia to Leibniz) use a lot of PTC.

The PCA graphic for the seven PoS (fig. 41) differentiates the arithmetic texts relatively well from the control groups and even more neatly from the poetry and Vulgate out-groups, the only exceptions being Ps-Bede and Euler. They also group quite neatly away from the average of thematic samples; the arithmetic average is closest to the medical texts. Unsurprisingly, the post-Scientific-Revolution authors tend to end up more in the centre of the plot, in the region of the 'new science' sample. The Euclid translation (Anonymus Siculus) is found at the lower-left extreme, away from 'normal' Latin. Even a cursory glance at the tables above shows that the language of Ps-Bede differs markedly from the rest.

17 It should be noted that numerals are counted as ADJ.

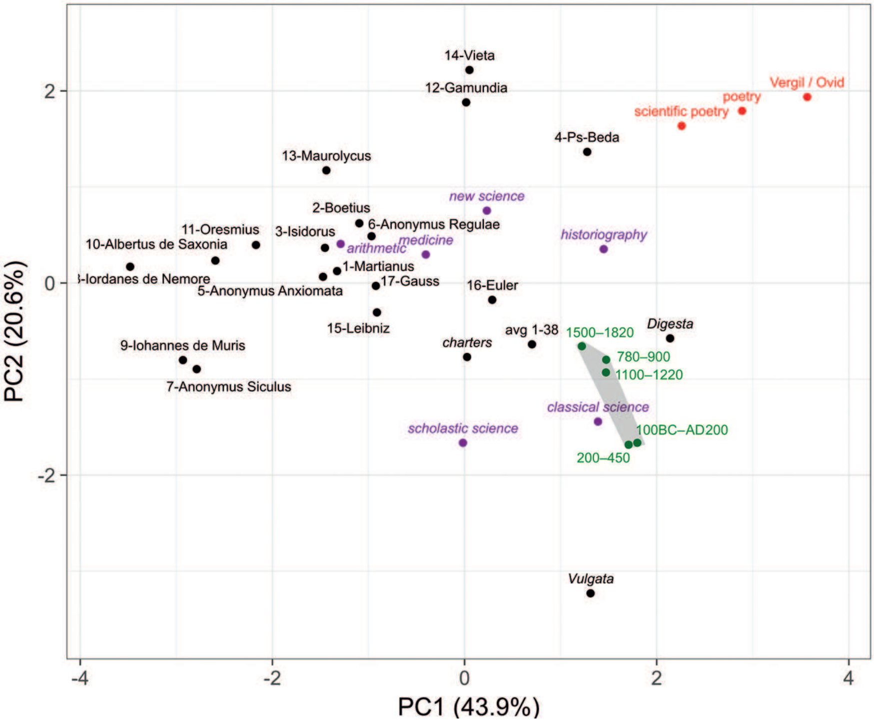

Fig. 41: PCA for the seven PoS.

If those parameters that differ more than 3 stdevs between the average of arithmetic and the benchmark are again chosen (ADJ, N, PREP, NOM, ESSE, PRON: POSS, 3rd PAS, ADJ-SUF, adding again 1st SG, and not using entropy for lack of reliable data), the result moves the arithmetic texts further away from the benchmark (fig. 42). Although the arithmetic texts still cluster neatly (again except Ps-Bede), the scholastic sample now ends up among them. The early modern texts (11–15, except Euler and Gauß), again, have a tendency to form a subgroup among the arithmetic texts.

In all the plots, the general prose samples, the poetry samples, and the Vulgate are clearly differentiated from the arithmetic texts, with the exception of Ps-Bede, a text that, indeed, differs quite markedly from the rest as it is much more of a merely didactic work than the others. For arithmetic texts, the PoS composition seems to differ more strongly from other kinds of Latin, including other scientific Latin. The Scientific Revolution authors Gamundia, Maurolycus, Vieta, and Leibniz (in one plot also Gauß) are usually close together. Euler seems to be an exception, using more conventional Latin. Somewhat surprisingly, in all cases pre- and post-twelfth-century authors could not be separated using these values.

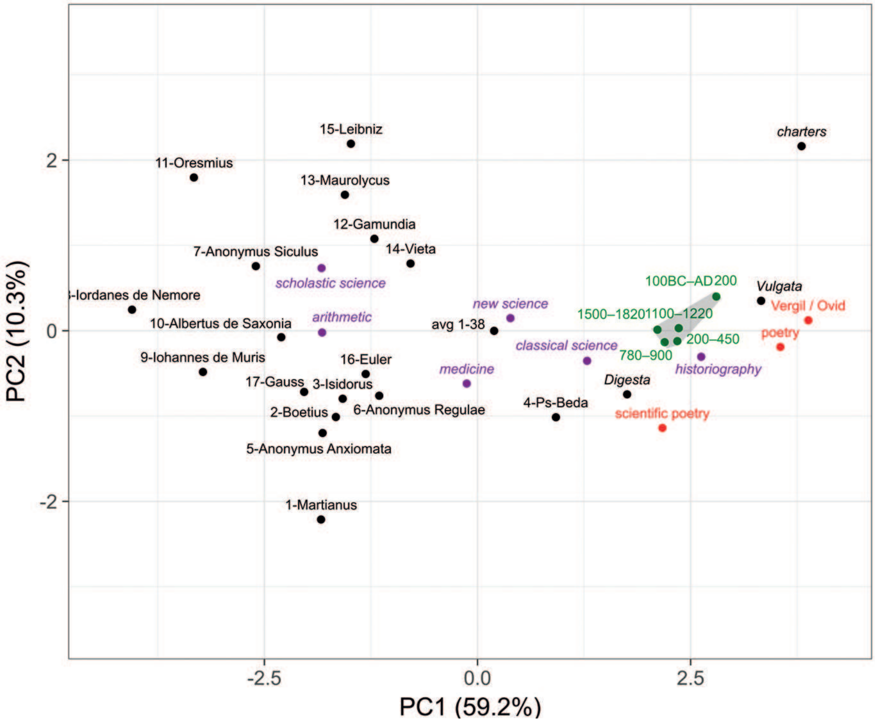

Fig. 42: PCA with the nine parameters with more than 3 stdevs average difference from benchmarks.

Finally, a stylometry plot based on the most common words using the same criteria as in the previous chapter is presented, this time only for words, not for lemmata. The tree in figure 43 corroborates the finding that the language of arithmetic differs strongly from that of the non-arithmetic texts used as out-groups. The groups within the arithmetic texts are much less pronounced, but it is conspicuous that the first Latin Euclid translation is very close to the root of all arithmetic texts. This shows nicely the enormous influence of Euclid's thought and diction on all later Latin writers.[18] The pre-Euclidean texts (numbers 1–6) form a neat group, as do the mediaeval ones and the early modern ones (15–17).

18 It has been pointed out above that the texts older than Siculus are also heavily indebted to Euclid.

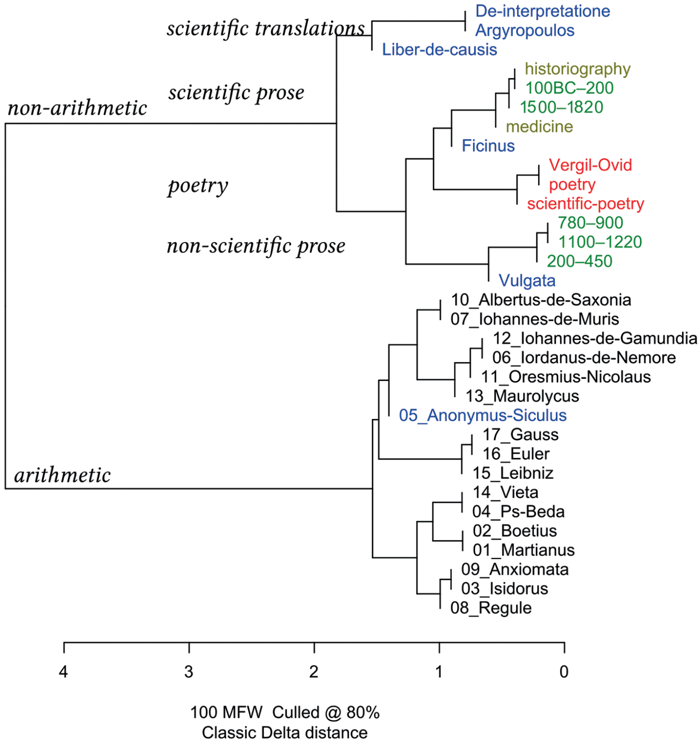

Fig. 43: Stylometry plot for the 100 most common words.

The results certainly do imply that arithmeticians – and possibly other ‘hard’ scientists within a clearly delimited field – used a rather uniform and unchanging type of language that contrasts strongly with other types of Latin. There are only few differences in the results based on the two different methods; this time, the stylometry plot seems to correspond even better to expectations. In contrast to the general sample in the previous chapter, there is a less strong caesura around the twelfth century – typical scholastics did not do arithmetic. But there is a strong dependence on Euclid’s *Elementa* in general, which was translated fully into Latin by the anonymous Sicilian around 1175. Indeed, also in this field the amount and productivity of texts increases very significantly in the twelfth century.

§5 Two more groups of less clearly scientific texts are now studied briefly, both of which would also seem to exhibit a rather uniform but different character linguistically: historiography and scientific/didactic hexametric poetry. For these, two corpora consisting of fifteen and ten texts respectively from republican times to modernity were defined. For the first, discursive prose texts about the history of a fixed topic were chosen; chronicles and similar more list-like texts were excluded. For both these groups of texts, it is less clear that they fulfil our criteria for science, as strictness of data and reasoning seems to be less crucial than rhetoric or poetic form for many writers. Above, the relation of *historia* to *scientia* was discussed (chap. 3 §5): it was stressed that some authors do use scientific approaches (e.g. Adam of Bremen in the sample), whereas others are rather propagandists (e.g. Liutprand). The data on the next pages show that these two groups of texts are quite homogeneous (although there are some atypical texts in the Middle Ages, especially Iohannes de Plano Carpini and *Macer Floridus*). The medical writers studied below (see chap. 21 and table 23) are also included in the data.

Table 19: The texts forming the two additional corpora on historiography and scientific poetry, a diachronic sample of fifteen and ten texts respectively.

Author and work[20]	Life dates	Main scientific topic, in modern terminology	Number of words,[21] average word length	See above
Sallust, *Bellum Iugurthinum*, ed. Ahlberg (1919)	86–ca. 35 BC	war against the Numidian King Jugurtha	22 6.04	
Livy, *Ab urbe condita*, ed. Foster (1919)	ca. 59 BC–ca. AD 17	history of the city of Rome	596 6.69	
Suetonius, *De vita caesarum*, ed. Ihm (1907)	ca. 70–ca. 130	biography of Roman emperors	72 6.26	
Rufinus, *Historia monachorum* PL 21 (1879)	345–411	history of monasticism	25 5.77	
Orosius, *Historiae adversum paganos*, ed. Zangemeister (1882)	385–420	salvation history	78 7.26	3 §5
Gregory of Tours, *Historiae*, ed. Krusch (1951)	538–594	history of the Franks	123 5.99	
Notkerus Balbulus, *Gesta Caroli Magni*, ed. Haefele (1959)	ca. 840–912	history of Charlemagne	17 6.24	
Liutprand of Cremona, *Antapodosis*, ed. Becker (1915)	922–972	polemical history of his time	36 6.12	

19 Red means less than the average minus 1 stdev, green more than the average plus 1 stdev.
20 In thousands. The shortest texts are around 8,000 words; most are much longer.

Table 19: (continued)

Author and work[20]	Life dates	Main scientific topic, in modern terminology	Number of words,[21] average word length	See above
Adam of Bremen, *Gesta Hammaburgensis ecclesiae pontificum*, ed. Schmeidler (1917)	–1081	history of the Diocese of Hamburg and the Far North	42 6.08	3 §5
William of Malmesbury, *Gesta regum Anglorum* PL 179 (1899)	ca. 1095–ca. 1143	Anglo-Saxon history	116 6.22	
Iohannes de Plano Carpini, *Historia Mongalorum*, ed. Leonardi (1989)	ca. 1185–1252	history of the Mongols	20 5.50	
Theodoricus de Niem, *Historie de gestis Romanorum principum*, ed. Colberg (1980)	1340–1418	history of the emperors of the Holy Roman Empire	33 6.09	
Laurentius Valla, *Gesta Ferdinandi regis Aragonum*, ed. Besomi (1973)	1406–1457	history of Ferdinand I of Aragon	42 5.81	
Nicola Orlandini, *Historia Societatis Iesu* (Romae, 1615)	1554–1606	history of the Jesuit Order	1,391 6.53	
Iacobus Augustus Thuanus, *Historiae sui temporis* (Paris, 1606–1609)	1553–1617	history of the religious wars from 1545 onward	1,279 6.06[21]	

21 Average word length of these texts: 6.18 ±0.42, somewhat longer than the benchmark: 5.95 ±0.32.

Table 19: (continued)

Author and work[20]	Life dates	Main scientific topic, in modern terminology	Number of words,[21] average word length	See above
Lucretius, *De rerum natura*, ed. Martin (1934)	ca. 99–ca. 55 BC	natural philosophy, Epicureanism	49 5.58	8 §6
Manilius, Astronomica, ed. van Wageningen (1916)	early 1st century AD (?)	astronomy and astrology	28 5.77	5 §2
Anonymus, *Aetna*, ed. Duff (1934)	before 79	geology	4 5.74	8 §8
Avienus Rufius Festus, *Ora maritima*, ed. Schulten (1922)	ca. 305–ca. 375	geography	4 5.80	5 §2
Walahfrid Strabo, *Hortulus* PL 114 (1879)	ca. 808–849	botany	3 5.95	5 §2
Macer Floridus, *De viribus herbarum*, ed. Baudet (1845)	11th century	medical botany	14 5.84	5 §2
Marcellus Palingenius Stellatus, *Zodiacus vitae*, ed. Chomarat (1996)	ca. 1500–1543	ethics, metaphysics, satire	66 5.60	5 §2
Bruno, *De monade, numero et figura*, ed. Fiorentino (1879–1891)	1548–1600	arithmology	10 5.83	12 §3
Benedictus Stay, *Philosophia versibus tradita* (Romae, 1747)	1714–1801	history of philosophy	82 5.64	13 §4
Bernardus Zamagna, *Navis aeria* (Romae, 1768)	1735–1820	airships	13 5.65[22]	13 §4

22 Average word length of these texts: 5.91 ±0.49, almost the same as the benchmark: 5.95 ±0.32, but significantly longer than the poetry sample: 5.49.

Table 20: Showing the same values as above for the general corpus (see table 13) for texts of historiography, scientific poetry, and medical writers (table 23 provides information about works and editions used). They resemble those for Pliny (from table 13 above, reproduced here for comparison). Again, the first four values, the 1st person singular, and the 3rd person passive are given as percentages of V, the cases as percentages of N (VOC and LOC not included). All other values are simple percentages, except ABL ABS, which is given in occurrences per 1,000 words. Colours are used as in table 12. Entropy values with * are not trustworthy as the texts are too short; the averages were calculated without them.

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Sallust	41.32	11.18	20.13	24.44	19.27	13.48	32.23	35.02	2.78	3.19	2.68	1.31	3.63	6.42	0.79	2.97	0.90	5.85	9.40
Livy	33.86	17.05	13.49	30.71	20.18	15.28	32.96	31.58	3.29	2.73	2.06	0.69	1.69	6.05	1.03	2.75	0.35	6.31	9.55
Suetonius	35.74	15.77	11.09	33.71	12.48	16.41	35.05	36.06	1.71	2.56	2.26	0.71	1.59	6.42	1.52	3.27	0.49	9.72	10.10
Rufinus	44.52	16.28	12.41	23.50	17.78	19.43	31.57	31.21	2.77	3.17	2.46	1.24	2.60	7.77	0.93	3.48	2.20	2.66	9.12
Orosius	41.87	11.07	8.43	35.08	18.08	18.15	29.62	34.15	2.67	2.63	1.90	0.79	2.30	7.25	1.14	3.22	0.85	5.24	9.52
Gregory of Tours	46.74	12.04	8.64	29.56	19.61	15.21	30.09	35.09	2.77	3.57	2.50	1.49	4.11	6.31	1.02	2.62	2.09	6.31	8.44
Notker	31.83	19.36	13.00	31.88	15.42	17.92	32.22	34.44	1.83	2.64	2.45	1.74	4.15	5.41	2.34	3.41	1.24	3.42	9.62
Liutprand	45.08	15.82	12.23	23.61	21.83	16.24	28.97	32.97	2.50	3.89	2.90	1.48	3.21	6.77	1.26	3.45	1.37	5.21	9.64
Adam of Bremen	48.49	10.71	11.09	27.15	18.33	19.25	28.24	34.19	2.91	4.00	1.94	1.65	2.81	8.03	1.51	3.43	1.27	2.30	9.53
William of Malmesbury	41.10	14.62	9.26	31.33	18.17	19.43	28.09	34.32	1.76	3.29	2.31	1.41	4.19	6.51	1.64	3.82	0.83	8.00	10.31
Iohannes de Plano Carpini	61.23	11.41	10.81	12.98	18.42	11.65	37.79	32.15	3.54	3.66	2.88	0.89	0.39	8.90	0.51	2.33	1.27	1.31	8.41
Theod. de Niem	47.66	11.40	8.94	28.35	19.89	16.43	29.47	34.21	1.74	2.58	1.58	1.58	2.61	7.82	2.02	2.79	0.90	6.24	9.30

Table 20: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Valla	39.75	16.45	14.10	23.21	18.94	13.25	30.90	36.91	3.55	3.31	3.19	1.16	3.17	8.41	0.86	2.88	1.14	7.20	9.62
Orlandini	37.25	17.03	11.43	27.30	17.85	19.12	28.60	34.44	2.21	3.07	1.13	1.00	1.78	7.81	1.74	4.59	0.62	6.26	10.19
Thuanus	31.78	18.18	10.95	34.27	14.57	15.50	30.14	39.79	2.16	3.64	0.99	0.82	0.91	8.96	1.25	3.41	0.52	11.89	9.92
avg	**40.12**	**14.82**	**12.43**	**29.06**	**18.08**	**16.51**	**31.59**	**33.82**	**2.54**	**3.05**	**2.40**	**1.18**	**2.91**	**6.55**	**1.25**	**3.15**	**1.19**	**5.59**	**9.42**
stdev	*5.60*	*3.04*	*3.64*	*4.64*	*2.94*	*1.92*	*1.99*	*1.74*	*0.53*	*0.49*	*0.32*	*0.40*	*1.02*	*0.72*	*0.49*	*0.33*	*0.68*	*2.13*	*0.48*
Charters	53.26	10.82	10.90	21.99	19.10	17.96	25.30	37.65	2.16	2.48	1.74	1.71	11.03	5.19	1.88	3.82	0.59	4.06	8.60
avg 'science' (chap. 18)	**51.43**	**13.29**	**12.40**	**18.41**	**27.96**	**17.82**	**25.80**	**28.43**	**4.75**	**3.94**	**3.00**	**0.58**	**2.46**	**12.75**	**1.98**	**4.66**	**1.85**	**2.68**	**8.84**
avg benchmark	**49.31**	**14.31**	**12.42**	**18.64**	**23.71**	**18.38**	**28.45**	**29.46**	**3.72**	**3.53**	**2.92**	**1.56**	**4.44**	**9.14**	**1.25**	**4.19**	**1.46**	**3.03**	**9.15**
Lucretius	43.78	13.84	22.13	18.36	22.73	15.49	30.68	31.10	2.56	3.28	3.10	0.53	2.14	7.63	0.73	0.61	1.38	4.61	9.66
Manilius	51.71	8.82	8.48	28.17	21.14	12.33	37.94	28.58	1.99	2.38	1.11	0.86	0.79	7.35	1.17	0.59	0.45	7.04	9.77
Aetna	52.61	10.35	11.29	23.69	27.11	11.36	31.98	29.55	2.36	1.86	1.46	0.60	0.93	5.97	0.96	0.67	0.50	5.01	*
Avienus	58.08	8.15	11.43	20.89	23.84	18.86	34.07	23.22	2.80	1.55	1.14	0.57	2.89	7.23	1.44	1.22	1.12	0.82	*
Walahfrid	42.96	12.30	15.70	26.22	21.24	17.84	28.14	32.78	0.91	2.08	2.25	0.74	4.15	9.63	1.98	1.08	0.47	5.04	*
Macer Floridus	47.11	8.94	11.81	29.17	23.37	12.17	30.67	33.78	2.09	1.89	3.11	0.07	0.90	12.64	1.64	0.68	0.17	3.96	8.93
Palingenius	54.74	11.37	14.45	14.88	31.24	12.29	27.76	28.71	3.57	2.94	2.31	0.73	3.45	7.83	1.29	1.06	1.20	3.43	10.07
Bruno	50.53	10.71	7.11	27.73	31.91	15.71	23.55	28.83	3.50	2.98	2.88	0.27	1.38	7.06	1.01	1.59	0.62	3.61	9.67

Table 20: (continued)

Text	IND	SUB	INF	PTC	NOM	GEN	ACC	ABL/DAT	ESSE	REL	CONJ:S	PRON:POSS	1st SG	3rd PAS	ADJ-SUF	N-SUF	Modifiers	ABL ABS	Entropy
Stay	41.03	16.31	17.46	21.41	22.47	14.79	29.99	32.76	2.67	3.10	2.96	0.64	2.13	7.16	0.74	1.01	0.91	4.38	9.90
Zamagna	36.99	15.55	12.14	30.17	21.80	13.24	32.76	32.20	0.81	1.83	2.07	0.65	2.52	4.30	1.19	0.28	0.66	5.74	10.17
avg	**47.95**	**11.63**	**13.20**	**24.07**	**24.68**	**14.41**	**30.75**	**30.15**	**2.33**	**2.39**	**2.24**	**0.57**	**2.13**	**7.68**	**1.22**	**0.88**	**0.75**	**4.36**	**9.68**
stdev	*6.68*	*2.84*	*4.41*	*5.08*	*4.01*	*2.56*	*3.89*	*3.10*	*0.93*	*0.63*	*0.79*	*0.23*	*1.15*	*2.21*	*0.39*	*0.38*	*0.39*	*1.64*	*0.40*
Poetry corpus	**49.57**	**11.06**	**10.78**	**23.06**	**25.31**	**11.30**	**32.92**	**30.48**	**1.99**	**2.23**	**1.78**	**1.54**	**5.23**	**4.57**	**1.35**	**0.87**	**0.61**	**5.49**	**9.92**
Celsus	52.45	9.52	12.85	16.64	28.56	14.42	25.79	31.23	5.44	3.43	3.57	0.13	1.65	10.83	0.95	2.36	1.15	4.78	9.21
Gariopontus	48.56	16.54	11.11	16.36	22.09	14.67	28.23	35.01	3.88	1.76	3.80	0.12	0.87	8.92	0.74	3.62	1.84	4.91	*
Gordonius	58.42	13.06	8.15	14.58	32.15	15.54	26.70	25.62	5.68	2.24	4.42	0.21	1.03	15.63	2.13	1.55	2.56	1.00	8.15
Vesalius	46.67	13.51	9.41	24.63	19.61	26.96	24.70	28.73	1.71	3.54	1.94	0.36	3.44	18.91	1.20	1.78	1.24	3.03	9.20
Sennert	46.74	16.37	12.25	17.50	25.42	17.71	26.75	30.12	3.28	3.42	2.68	0.27	1.09	15.36	1.53	3.76	1.66	3.12	9.49
von Bene	47.57	10.28	5.52	32.26	25.00	20.15	28.42	26.43	2.12	1.48	1.83	0.14	2.08	15.98	4.05	3.95	0.27	4.76	9.47
avg	**50.07**	**13.21**	**9.88**	**20.33**	**25.47**	**18.24**	**26.76**	**29.52**	**3.69**	**2.65**	**3.04**	**0.21**	**1.69**	**14.27**	**1.77**	**2.84**	**1.45**	**3.60**	**9.10**
stdev	*4.62*	*2.95*	*2.76*	*6.80*	*4.47*	*4.79*	*1.42*	*3.43*	*1.65*	*0.93*	*1.06*	*0.10*	*0.97*	*3.69*	*1.22*	*1.07*	*0.77*	*1.53*	*0.55*
Pliny	47.47	9.75	11.77	27.87	19.07	17.43	24.51	38.99	2.12	2.49	1.71	0.31	1.23	13.56	1.93	2.26	0.84	7.81	10.38
avg 'science'	**51.43**	**13.29**	**12.40**	**18.41**	**27.96**	**17.82**	**25.80**	**28.43**	**4.75**	**3.94**	**3.00**	**0.58**	**2.46**	**12.75**	**1.98**	**4.66**	**1.85**	**2.68**	**8.84**
avg benchmark	**49.31**	**14.31**	**12.42**	**18.64**	**23.71**	**18.38**	**28.45**	**29.46**	**3.72**	**3.53**	**2.92**	**1.56**	**4.44**	**9.14**	**1.25**	**4.19**	**1.46**	**3.03**	**9.15**
stdev	*3.02*	*1.73*	*1.97*	*1.64*	*1.60*	*1.56*	*1.00*	*2.40*	*0.29*	*0.56*	*0.39*	*0.23*	*1.93*	*0.94*	*0.17*	*0.51*	*0.28*	*0.41*	*0.20*

Table 21: PoS values for the additional corpora as percentages. See table 12 for the general corpus.

	ADJ	ADV	CONJ	N	PREP	PRON	V
Sallust	10.87	8.92	9.72	29.85	7.42	10.23	22.99
Livy	12.80	7.85	7.06	32.52	9.08	7.70	22.99
Suetonius	12.11	8.91	10.10	30.51	8.67	7.13	22.56
Rufinus	13.65	8.64	7.39	30.89	8.56	8.61	22.25
Orosius	8.25	9.38	10.53	25.27	9.83	12.90	23.84
Gregory of Tours	9.41	8.23	7.65	24.54	9.96	14.10	26.11
Notker Balbulus	13.79	8.95	9.17	22.71	9.12	13.46	22.80
Liutprand of Cremona	12.70	10.07	7.29	24.63	6.75	14.23	24.33
Adam of Bremen	13.41	8.45	7.50	26.74	9.64	12.59	21.67
William of Malmesbury	12.35	7.80	8.06	32.58	7.89	9.55	21.78
Ioh. de Plano Carpini	8.80	9.10	12.80	20.46	11.36	14.72	22.76
Theodericus of Niem	13.73	7.92	8.33	27.07	10.10	11.66	21.19
Valla	10.05	9.73	10.31	26.42	8.99	10.50	24.00
Orlandini	12.81	10.81	6.79	29.78	9.20	8.92	21.69
Thuanus	10.70	9.66	7.56	29.91	11.04	8.04	23.09
avg	**11.70**	**8.87**	**8.61**	**27.61**	**8.68**	**11.05**	**23.48**
stdev	*2.01*	*0.68*	*1.42*	*3.71*	*1.11*	*2.97*	*1.26*
Charters	11.90	7.86	11.61	26.24	11.10	12.90	18.38
avg 'science' (chap. 18)	**12.36**	**9.74**	**9.86**	**24.49**	**9.13**	**12.55**	**21.87**
avg benchmark	**10.06**	**8.95**	**9.93**	**25.69**	**8.30**	**14.13**	**22.93**
Lucretius	12.00	10.42	9.84	26.62	6.35	10.39	24.39
Manilius	14.48	4.88	7.42	33.94	6.68	8.10	24.50
Aetna	16.07	7.95	7.93	30.20	3.90	8.29	25.67
Avienus	15.71	9.89	6.32	32.30	6.18	8.88	20.72
Walahfrid	17.36	7.32	6.48	34.52	3.66	7.77	22.89
Macer Floridus	12.45	6.22	7.20	29.00	4.42	10.19	30.53
Palingenius	15.08	10.21	9.47	25.70	3.52	11.28	24.76
Bruno	16.37	7.36	8.56	30.09	5.88	9.35	22.37
Stay	12.99	11.27	8.59	25.86	6.52	9.92	24.86
Zamagna	17.19	9.68	8.68	28.41	5.68	7.72	22.64

Table 21: (continued)

	ADJ	ADV	CONJ	N	PREP	PRON	V
avg	**14.97**	**8.52**	**8.05**	**29.66**	**5.28**	**9.19**	**24.33**
stdev	*1.93*	*2.08*	*1.19*	*3.18*	*1.26*	*1.23*	*2.63*
Poetry corpus	**15.92**	**7.04**	**7.09**	**30.90**	**4.27**	**10.21**	**24.58**
Celsus	12.28	11.48	10.69	23.68	7.12	11.16	23.60
Gariopontus	11.59	8.54	16.64	23.58	7.78	8.47	23.40
Bernardus de Gordonio	15.92	10.37	16.25	20.22	10.59	6.46	20.18
Vesalius	16.31	11.81	7.69	28.15	7.15	10.71	18.18
Sennert	13.15	10.67	11.85	23.85	8.53	10.11	21.85
von Bene	20.36	9.89	8.10	27.61	9.19	4.99	19.86
avg	**14.93**	**10.46**	**11.87**	**24.52**	**8.39**	**8.65**	**21.18**
stdev	*3.28*	*1.18*	*3.87*	*2.94*	*1.34*	*2.48*	*2.14*
Pliny	14.40	7.14	8.10	32.75	8.79	8.78	20.03
avg ‘science’ (chap. 19)	**12.36**	**9.74**	**9.86**	**24.49**	**9.13**	**12.55**	**21.87**
avg benchmark	**10.06**	**8.95**	**9.93**	**25.69**	**8.30**	**14.13**	**22.93**
stdev	*0.87*	*0.53*	*0.43*	*1.40*	*0.77*	*1.12*	*1.03*

Again using PCA with the nine values that seemed distinctive for science, the historical texts do not form a very neat cluster and generally remain between the non-scientific benchmark samples and the poetry samples, but far from the science samples (fig. 44). This indicates that historiography used a rather less technical language than the other fields hitherto considered. Methodologically more sound historians cannot be differentiated from ‘propagandists’: the difference clearly lies in the content, not in the language. Suetonius is the furthest from the benchmark samples; some authors are close to the charters sample – especially Sallust, Rufinus, Gregory of Tours – indicating a plausible kinship between these two kinds of texts. After all, many historical writers use charters as sources. Iohannes de Plano Carpini’s language differs conspicuously from the other authors.

The case is very different for scientific poetry (fig. 45): these texts cluster together much more neatly, indeed somewhere between other poetry and scientific prose texts (especially medicine) and far from the benchmark samples – quite as expected. Stylometric plots for these two samples produce similar results: scientific poetry groups neatly, historiography does not (plots not printed).

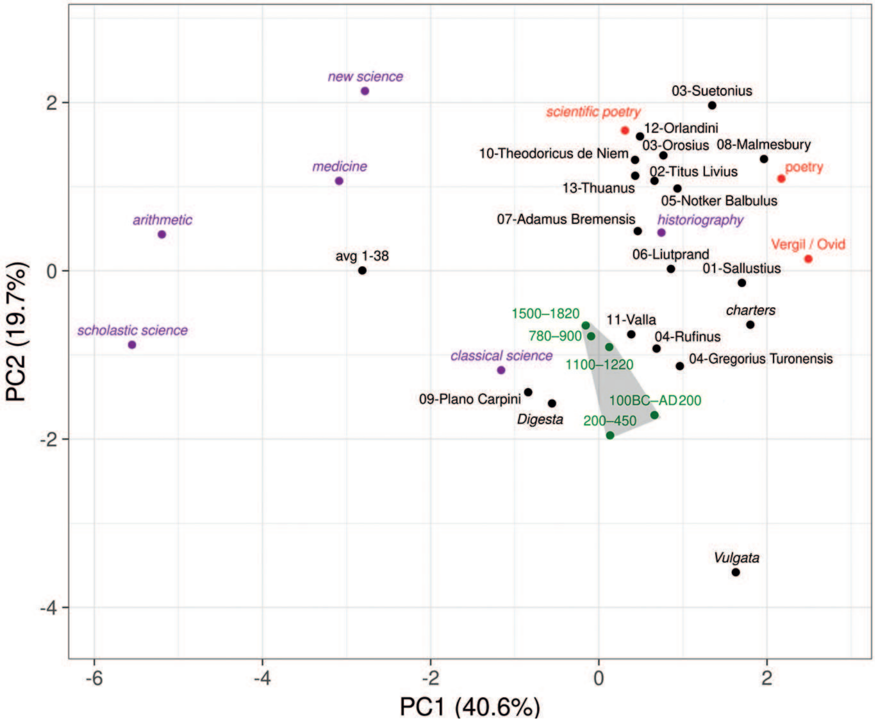

Fig. 44: Plot using the nine parameters from above (see fig. 38, except entropy) for the historiographical texts. The texts group around the benchmark samples.

§6 For both these additional samples, it has become clear that the language differs strongly from the scientific texts studied so far. Table 22 summarises the conspicuous values for the corpora and most clear-cut groups of texts that have been studied. It becomes clear that the historiographical sample differs significantly – even more so than the scientific poetry sample – from the clearly scientific samples (general sample, scholasticism, arithmetic, medicine, less clearly jurisprudence). Among the latter, it is the medical texts that differ most strongly; the other three samples agree in the parameters ESSE, ADJ-SUF, modifiers, and entropy (<u>underlined</u>). 1st SG, 3rd PAS, and PRON:POSS may be the most distinctive values for scientific texts (**bold**). The scholastic sample represents the most extreme type of scientific Latin, focusing on NOM, IND, and using suffixes and modifiers, apparently in emulation of Greek, while CONJ and PREP may be more used than bare clauses and cases in order to increase perspicuity – all in all, approaching an artificial logical language and language engineering.

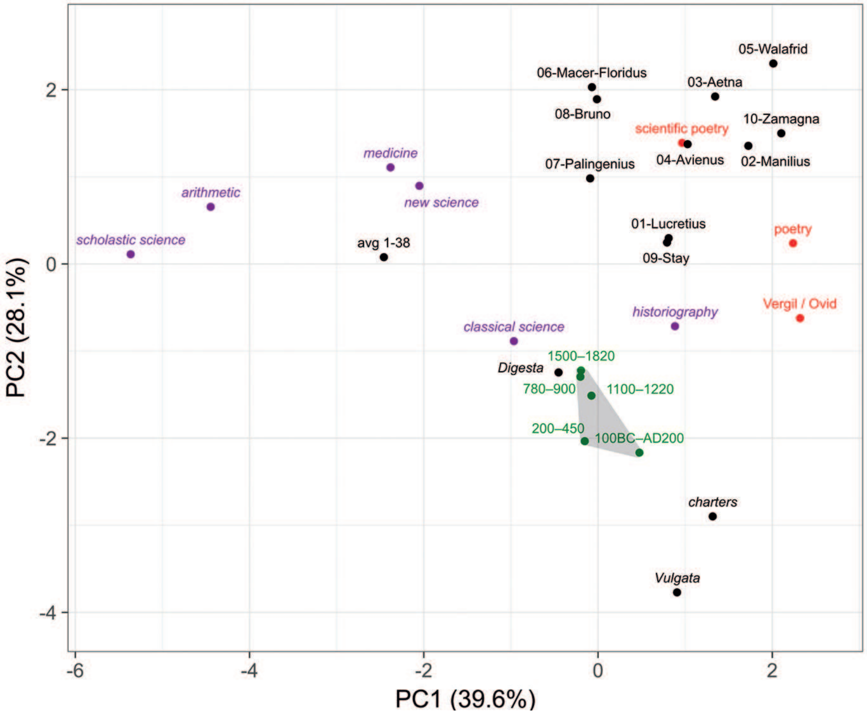

Fig. 45: Plot using the nine parameters from above (see fig. 39) for scientific poetry. The texts are clearly apart from the rest, including normal poetry.

Table 22: The table summarises the average values of the corpora studied in contrast to the prose benchmark samples. +++: more than 3 stdevs above the benchmark samples, + more than 1 stdev above; analogously for – and – – –. Parameters that are not included are, therefore, within 1 stdev of the benchmark average. Non-scientific poetry is shown as an out-group. Especially interesting parameters are marked.

	+++	+	–	– – –
General sample from chap. 18 (40 texts)	NOM, ESSE, **3rd PAS**, ADJ-SUF	ADJ, ADV, PREP, N-SUF, modif.	N, PRON, V, ACC, **1st SG**, entropy	**POSS**
Scholasticism[23]	ADV, NOM, ESSE, **3rd PAS**, ADJ-SUF, modif.	ADJ, CONJ, PREP, IND, REL, N-SUF	SUB, PTC, GEN, ABL/DAT, **1st SG**	N, ACC, **POSS**, ABL ABS, entropy
Arithmetic	ADJ, PREP, NOM, ESSE, **3rd PAS**, ADJ-SUF	CONJ, modif.	PRON, V, INF, GEN, ACC, ABL/DAT, **1st SG**, ABL ABS	N, **POSS**, entropy

23 Average from the texts in the general corpus by Albertus, Aquinas, Duns, and Ockham, who seem especially typical.

Table 22: (continued)

	+++	+	–	– – –
Medicine	ADJ, CONJ, **3rd PAS**, **POSS**, ADJ-SUF	ADV, NOM, ESSE, ABL ABS	N, V, INF, GEN, ACC, REL, **1st SG**, N-SUF	PRON
Jurisprudence[24]	ESSE, CONJ:S	CONJ, V, SUB, INF, ABL/DAT, **3rd PAS**, N-SUF	ADJ, IND, PTC, GEN, **1st SG**, ADJ-SUF	**POSS**
Historiography	PTC, ACC, ABL ABS	ADJ, N, PREP, ACC, ABL/DAT, entropy	CONJ, PRON, IND, GEN, CONJ:S, **POSS**, **3rd PAS**, N-SUF, modif.	NOM, ESSE
Scientific poetry	ADJ, PTC, ABL ABS	N, V, ACC, entropy	PRON, SUB, GEN, REL, CONJ:S **1st SG**, **3rd PAS**, modif.	CONJ, PREP, PRON, ESSE, **POSS**, N-SUF
Non-scientific poetry	ADJ, N, ACC, ABL ABS, entropy	V, PTC, NOM	SUB, REL, ADJ-SUF	ADV, CONJ, PREP, PRON, GEN, ESSE, CONJ:S, **3rd PAS**, N-SUF, modif.

§7 As a summary of these corpus approaches, a final plot (fig. 46) shows all the used texts together, marking the disciplines or genres in different colours. The colours show that most groups cluster together quite closely, from left to right: arithmetic, scholastic authors (some early and late ones are not coloured), translations from Greek, medical writers, juridical texts, didactic poetry, historiography. Only the medical and juridical writers are quite scattered, and only the historiographical ones are close to the benchmark samples. Thus, historiography tends to remain close to 'normal' prose, indeed between it and the charters sample; scientific poetry is also quite apart from the other texts, between non-scientific poetry and scientific prose. Modern human-science authors (Vossius, Kircher, Kretschmann) seem to use a style between that of historiographers and the natural scientists of the Scientific Revolution, who are situated quite in the middle of the plot (Copernicus, Galileo, Newton). For Boethius and Isidore, there are two samples each, one from the general texts and one of an arithmetic text. It is interesting to note that the arithmetic ones group quite far away from the general ones, as expected within the arithmetic group. Ficino's translation and Iohannes de Plano Carpini behave unexpectedly for their groups.

24 Average of Gaius, *Pauli sententiae*, and *Digesta*.

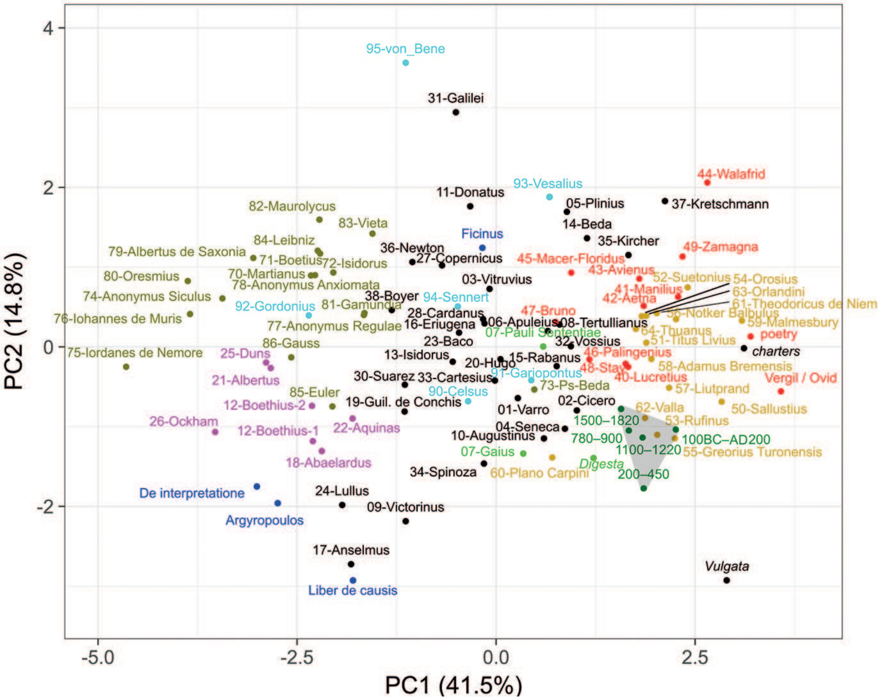

Fig. 46: A plot using the same nine parameters (see fig. 38), this time including all the texts considered (but no groups). The colours highlight disciplines and genres: benchmark (green), translations (blue), medicine (light blue), scientific poetry (red), historiography (yellow), arithmetic (brown), juridical (light green), and scholastic (pink).

§8 Some general conclusions from the numerical research in this and the previous two chapters can now be drawn. The general corpus showed the existence of some quite neatly differentiable styles of Latin scientific prose (summarised in chap. 19). By means as simple as the PoS distribution, scholastic texts can be clearly separated from classicist or technical ones. The parameters that, it was hoped, would be significant for scientific writing (departing from what is known about scientific English and German) have led to mixed results for Latin: some of them differ strongly from other Latin, while others do not. The former are not always the same ones as those known to differ for scientific English. As in English scientific language, in Latin science PREP, 3rd PAS, and ESSE are indeed more common, but CONJ or GEN are not. The passive voice is more common in scientific Latin than otherwise, but not in such an extreme way as in contemporary scientific English. The 1st SG and possessive pronouns are also less common. Some features typical for scientific English do not exist in the same way in Latin, such as the -ing-form. Unexpectedly, possible Latin counterparts such as participles, infinitives, and the *ablativus absolutus* are less common in scientific writing than otherwise; even the relative pronoun (REL) is only marginally more common in the general science corpus than in the benchmark samples. Also surprisingly, subordination (CONJ:S) does not seem to be significantly more common in scientific Latin texts. The greater frequency of suffixes is a feature not previously studied for scientific English; ADJ suffixes, in particular, are conspicuous in scientific Latin. Other features with no known corresponding behaviour in scientific English are higher numbers of typically Greek sentence-modifying particles and lower entropy. The lower entropy may indicate a smaller density of information (which would be unexpected) and/or more monotone vocabulary and less *variatio* (which would be expected).

In some fields, a rather coherent type of language could be found: arithmetic, historiography, scientific poetry, scholasticism, and to a lesser extent medicine and jurisprudence. The arithmetic corpus has revealed an especially monolithic style these authors have used for over more than a millennium; it proved possible to link it to Euclid. Of course, this 'hard' science is especially little prone to rhetoric and linguistic variation. Numerals are necessarily among the most common words, and this science is based on proofs, which tend to be linguistically monotonous. Scientific texts translated from Greek tend to have more modifier particles (unsurprisingly) but also more CONJ and PREP, more NOM and IND, and lower entropy. It would be interesting to study which of these factors represent general differences between Greek and Latin. Some typically mediaeval Latin features were also found in passing (in the mediaeval benchmarks in contrast to those before and after): lower numbers of INF and, less clearly, lower numbers of ADJ and lower entropy. The kind of scientific Latin that departed the most from normal prose was clearly scholastic Latin. This most far-reaching approach to Latin language engineering was reined in by humanist disdain for such 'ugly' Latin. The two later typical forms of Latin science, that of the natural-science revolution and that of early modern human sciences and scholarship, deviated less from 'normal' Latin. Apart from this development, clear diachronic change was rarely observed; only in the arithmetic sample texts, pre-Euclid-translation texts and modern authors (Leibniz, Euler, Gauß) were set apart, at least in the plots based on the most common vocabulary (fig. 43). It may be pointed out that in general, Latin scientific language does not differ from non-technical language as much as is the case with some other languages. For instance, although there are slightly different ratios of cases used in some genres (as was seen above), there are no special uses of cases as there are in scientific Sanskrit.[25]

25 This very elaborate system is described by Jacobi (1970); see also Staal (1995).

It should be added that (as already indicated above) the quality of the data is not as good as it could be. Computational linguistics is currently in a phase of rapid development, and tools missing for Latin may soon be available (e.g. through Marco Passarotti's LiLa project). Tagging, the amount of data, and methodology will be much better in a mere ten years' time. It remains to be seen to what extent the results presented here will stand the test of time. After these first ever corpus-based studies of the Latin used by scholars and scientists, for the remainder of this book the scope will be widened and scientific Latin will be compared to other languages of science. We return first of all to the question of scientific vocabulary.

21 How are new scientific concepts expressed?

§1 In part 2 of this book, it became amply clear that Latin in general and for the most part has not been very open to *nova verba*.[1] This chapter tries to understand how new scientific insights have been expressed in Latin at various times throughout its history. Above (chap. 7), it was found that Democritus, Plato, and Aristotle used rather different approaches toward new words in science and philosophy. Plato in his rhetorically chiselled dialogues does not seem to coin new words at all, but this is an approach that is hardly feasible in positive sciences and is not emulated by Latin writers, who first of all had to stock up (so to speak) on the Greek scientific terms Latin lacked. In stark contrast, Democritus profusely used often poetic-sounding new words, especially compounds. Holding a typical μεσότης ('middle ground'), Aristotle does coin new terms, but in a well-measured fashion;[2] much more often, he uses already existing common words and gives them new technical meanings. Thus, we can distinguish between what we could tentatively call a 'Democritean' and an 'Aristotelian' approach to the coining of new terminology – leaving aside Plato's 'zero-approach'. To this can be added a 'modern' approach, used in many sciences in English today: the use of quite arbitrary *Kunstwörter*, which may contain the discoverer's name or may just be abbreviations, often acronyms, or complete fantasy coinings.[3] The only rule is that they have to be unambiguous within their field. After some new Latin coinings in the human sciences through the ages are considered, seven medical texts will be studied more deeply from the same perspective. The emphasis will lie on coinings of words (*Wortneuschöpfungen*) rather than of meanings alone (*Bedeutungsneuschöpfungen*), which are much harder to pin down unless the author introduces them *expressis verbis*.

Examples from the human sciences

§2 In Antiquity, Latin scientific authors tended to use already existing words to convey the meaning of Greek scientific terms. A set of four terms – three from Aristotle, one from Plato – illustrates what Latin authors did with them:

1 An earlier German-language stage of this chapter was presented at the congress 'Geschichte der Fach- und Wissenschaftssprachen: Identität, Differenz, Transfer', Würzburg, October 2017.
2 For examples see chap. 7 §5 above.
3 Thielmann (2009: 281) convincingly argues that acronyms are typical for the English scientific way of expression, in contrast to German. In Mediaeval Latin, they are very rare indeed (Stotz 1996–2004: VI, §32 =vol. 2, pp. 269–270).

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- ὕλη, in common language 'wood for construction', becomes in Latin *silva* (Lucretius) or usually *materia*. Both these words have very similar common meanings to the Greek one (e.g. in Vitruvius).
- ἀπόφανσις, in common language 'declaration, statement', is used in Aristotelian logic as 'predication'. In Latin it is usually rendered as *enuntiatio* ('declaration'), also becoming a technical term, for instance in Quintilian, *Institutio oratoria* VII.3.2, IX.1.23, ed. Rahn, vol. 2, pp. 58, 258.
- ἐνέργεια, one of the coinings of Aristotle (see chap. 7 §5 above). Latin writers struggled with a translation; *actus* or *actio* were tried, but both can stand for several other Aristotelian concepts as well. Eriugena tried *operatio,* Erasmus *efficacia* (in his translation of the New Testament). Modern Latin physicists just used the Greek word as *energia* (267 times in CC, as of April 2019).
- εἶδος and ἰδέα, the two words Plato uses for his 'idea', are derived from ἰδεῖν ('to spot'); both were in use already before Plato and meant 'form, shape, outward appearance'. Cicero translates with *species*, which means the same things. Only later Latin also uses *idea* in order to be more precise (eight times in Seneca, then often in the Church Fathers).[4]

Latin seems to behave similarly in fields that do not go back so decidedly to Greek models, as the juridical term *curator* ('legal guardian', non-technically just 'someone who takes care of'; Varro) suggests. Thus, an 'Aristotelian' approach to new coinings in Classical Latin times can be made out.

In contrast, scholastic Latin (see chap. 11 §2 above) seems to use a more 'Democritean' approach (although the words do look less poetic than in Democritus). Some examples of scholastic coinings: *aseitas* ('existing out of itself'), *compossibilis* ('possible at the same time with something'), or *mundialis* ('pertaining to the world').[5] There is an entire dictionary of such terminology specifically for Aquinas (by Schütz); some more special scholastic vocabulary will be listed below (chap. 24 §8).

Early modern times are possibly again somewhat more classicist in forming new words, but they still proceed similarly, for instance when speaking of a *stemma codicum,* a 'genealogical tree of the manuscripts' in textual criticism of the nineteenth century. Only in post-Latin times do tendencies change: many new words are derived from proper names (such as 'Lachmann's method', or 'Bédierism'), and in the later twentieth and twenty-first centuries what could be called an

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4 Some other, similar examples are discussed by Springhetti, *Latinitas fontium*, pp. 15–20.
5 First attested already in Tertullian (see chap. 9 §2 above), who seemed to have had such a 'Democritean' approach to language. See Wellstein (1999); chap. 9 §2 above.

American approach seems to gain ground:[6] here language games are used that become clear only *a posteriori* if at all; words may also be made up ungrammatically. Some random examples of such words without an etymology in the normal sense from psychology (see *OED* for more information):

- 'limerence' = 'state of falling in love', since 1978;
- 'bromance' = 'Platonic love between men', since around 1990;
- 'alief' = 'unconscious belief', since 2008.

Latin writers never gave up the 'Democritean' approach, which has great mnemotechnic advantages. Jesuit schoolbooks from the twentieth century (see chap. 15 §7) do take over some terms more or less tel-quel from the vernaculars, such as *elementa chromosomatum*, *conatus vitalis* ('élan vital'), *positivista,*[7] but often reformulate terms that are not transparent or well formed for a Latinist, such as *determinantia* for 'genes', or they speak of *evolutio ontogenetica* to make Darwin's mere 'evolution' clearer.

Of course, counterexamples to the proposed approaches will be found in Latin Antiquity, scholasticism, and beyond, as well as in post-Latin modern science, but the trend does seem clear. In order to find out whether this can be confirmed in a very different science, a closer look is now taken at a small corpus of medical texts.

Seven medical texts

§3 In order to study some more systematically gathered data, a small sample of Latin medical writers between Antiquity and the nineteenth century is examined.[8] A priori, one expects that such a practically relevant science may be more pragmatic with new terminology than the human sciences; but on the other hand, it equally goes back to Greek models and was often practised by highly educated Latinate men who – at least in Antiquity and early modern times – were usually also proficient in Greek. Seven texts from different times were chosen and loaded in Corpus Corporum for further study.[9] The main methodological approach will be to identify words that cannot be found in the large dictionary of Classical Latin by

6 It would not seem to be simply an Anglo-Saxon approach, but specifically a North American one. The people who coined the terms that follow were all Americans.

7 Examples from Carolus Boyer, *Cursus philosophiae*.

8 For the development of medical thought from Antiquity to around 1800, see Grmek (1993–2007).

9 For methodological reasons, direct translations from Greek were excluded.

Georges.[10] Some information about the size of these texts is presented in table 23; numbers in parentheses were obtained by counting only among the first 3,389 words, which is the length of the shortest text.

Table 23: Sample of seven medical Latin texts. §4 below discusses the 'unknown' words. The average word length among the seven texts is 5.94 ±0.34, which is very close to the benchmark samples: 5.95 ±0.32.

Author and work	Time	Number of words, average word length	Types	Lemmata[11]	'Unknown'[12]
Celsus, *De medicina*, ed. Marx (1915)	ca. 50	103,500 5.69	14,725 (1,517)	4,989 (603)	42[13] (0)
Isidore, *Etymologiae* IV: *De medicina*, ed. Lindsay (1911)	ca. 620	3,389 5.85	1,721 (1,721)	774 (774)	21[14] (21)
Gariopontus, *Liber passionarius* V.1–15[15]	ca. 1050	5,104 5.65	2,079 (1,494)	1,246 (880)	46 (23)
Bernardus de Gordonio, *De crisi et de diebus creticis,* ed. Guardo (2003)	ca. 1300	34,954 5.65	5,707 (1,235)	2,430 (705)	229 (38)
Andreas Vesalius, *De humani corporis fabrica* I (Basileae, 1543)	1543	102,882 6.19	14,814 (1,893)	4,316 (1,258)	ca. 335[16] (5)
Daniel Sennert, *Institutiones medicinae* (Wittebergae, 1628)	1628	568,858 6.00	50,553 (1,856)	9,596 (782)	ca. 905 (9)
Franz von Bene, *Elementa medicinae practicae* I (Pestini, 1833–1834)	1833	87,184 6.55	16,478 (1,703)	4,840 (733)	ca. 919 (25)

10 Georges covers the period up to and including Isidore, so in case of the two oldest writers in the sample, words that are only mentioned for these authors were sought.

11 Automatically counted by Corpus Corporum, without counting 'unknown' words.

12 Lemmata unknown to the Perseus PoS tagger and to the Georges dictionary.

13 As Georges also contains the vocabulary of Celsus and Isidore, values are given for lemmata that are quoted by no other earlier writer.

14 Words mentioned only in entry headings are not included; see below on them.

15 The work is not yet edited. I transcribed most of book V (sections 1 to 15) from the eleventh-century manuscript Wien, ÖNB 2425, online at http://data.onb.ac.at/rep/100199ED. My sample corresponds to some 5 % of the entire work.

16 For Vesalius, Sennert, and von Bene, these values are estimated by manually lemmatising all 'unknown' entries for the letter A and extrapolating. Sennert: total 7,255, letter A 561, yielding (after manual screnning) 70 lemmata; von Bene: total 2,015, letter A 193, yielding 88 lemmata. Vesalius often writes Greek and Hebrew names in their respective alphabets. These were not included in the counting.

The same PoS and other grammatical parameters that were used above (chaps 18–19) were also determined for these medical texts and printed above (tables 17–18). It was found that medical Latin corresponds well to other scientific Latin in some parameters (low: 1st SG, PRON:POSS; high: ADJ, 3rd PAS) but differs quite strongly from other, more theoretical sciences in others (not high: ESSE, PREP, N-SUF, modifiers; not low: ABL ABS, entropy). There were also some differences between early medical writers and later ones (especially up to and including Gordonius, low: PTC, CONJ:S), and sometimes Gordonius exhibited singular values (very low: ABL ABS, entropy; high: PREP) that seemed to point toward a more colloquial type of Latin. Especially the modern physicians exhibited values markedly similar to those of Pliny (in particular, very low: PRON, ESSE; low: CONJ, V, ACC; high: N; very high: PTC, entropy) – a 'nominal' type of language. It may be that only after the time of Gordonius was a relatively homogeneous medical Latin, strikingly similar to Pliny's 'plain' approach to language, used. In fact, the medical parts of Pliny's encyclopaedia were often reused into early modern times. It is, of course, not possible to say based on the data here how far this is convergence and how far Pliny was influential as a rôle model. For the three earlier texts in the sample, circumstances were different: Celsus wrote before Pliny, Gariopontus relied strongly on texts translated from Greek, and Gordonius relied on Arabic medicine. In the summary plot in figure 46 above, the medical texts did not cluster clearly against other scientific texts, Gordonius ended up among scholastic texts, Vesalius close to Pliny, von Bene far off and close to Galileo, the others quite in the centre of the plot (the Isidore sample was too small to be meaningfully plotted).

Before discussing these and other values further, a few words about the seven authors and their way of writing are included. Only the first two have been studied in depth to date; much of what has been found for Celsus will be valid for other medical Latin as well, although later authors create new words more liberally.

Cornelius Celsus, *De medicina* (ca. 25 BC–ca. AD 50): Celsus wrote a large encyclopaedia about the *Artes,* of which only the part about medicine is extant. The other parts apparently treated *De re rustica*, *bellica*, *rhetorica*, *philosophia*, *de iure civili*,[17] thus more practically usable sciences, excluding speculative (such as mathematical) ones whose province was still exclusively Greek. Celsus seems to have been the first Roman to write about medicine in Latin and can thus be com-

17 According to Schanz & Hosius (1922–1935: 2:722). On this author, see Schanz (1881); Schulze (2001). On his important rôle in the formation of medical Latin, see Langslow (1991). Edition used: Marx.

pared to Cicero, who first wrote about Greek philosophy in Latin (Brolén, *De elocutione*, p. 4). His language is rather classical and concise; as Schanz & Hosius put it: 'Seine Sprache ist rein und einfach und hält sich von allem Schwulste frei' ('his language is pure and simple, completely free from bombast'; 1922–1935: 2:726). Brolén formulated (*De elocutione*, pp. 7, 10):

> *numquam aut aliis verbis aut pluribus usus esse videatur, quam quibus opus erat ad res dilucide explicandas.*
> *Contra ubi vel exstabant latina verba ad res nominandas apta vel facile fingi poterant, a graecis videtur abstinuisse.*
> 'he never seems to be using other or more words than were necessary to explain things clearly.'
> 'On the contrary, where there existed Latin words apt for naming things or that could be easily formed, he seems to abstain from Greek ones.'

Schanz confirms (1881: 373) that this author always uses Latin names if available, for example *veratrum* (13 times), not ἐλλέβορος, for the plant 'hellebore'. Nonetheless, Celsus is, of course, not able to avoid Greek terminology altogether.[18] The word *graecus* (including the adverb *graece*) occurs 177 times in his work; in most of these passages, he is discussing terminology. At the very beginning he divides medicine thus (I, proem. 9, ed. Marx, p. 18):

> *Primam διαιτητικήν, secundam φαρμακευτιχήν, tertiam χειρουργικήν Graeci nominarunt.*
> 'The Greeks called the first part dietetics, the second pharmacology, the third surgery.'

Often he tells the reader the Greek name and a Latin translation or equivalent. It is interesting to look at how these are formed; some examples:
- φλεγμονή: *inflammatio* (I, proem. 16, ed. Marx, p. 19).
- μελαγχολία: *bilis atra* (II.1.6, p. 46).
- στραγγουρία: *urinae difficultas* (II.1.8, p. 47).
- ἄφθαι: *serpentia ulcera oris* (II.1.18, p. 49).
- φύμα: *in fistula urinae minutus abscessus* (II.8.20, p. 71).
- καχεξία: *malus corporis habitus* (III.1.22, p. 50).
- δυσεντερία: *intestinorum mala tormina* (IV.22.1, p. 175).
- ἀγκυλοβλέφαρος: *Interdum inter se palpebrae coalescunt, aperirique non potest oculus. Cui malo solet etiam illud accedere, ut palpebra cum albo oculi cohaerescat; scilicet quum in utroque fuit ulcus negligenter curatum* (VII.7.6A,

18 Fögen (2009: section 4.9) treats Greek loanwords in technical Roman writers such as Celsus.

p. 315). Both these diseases were apparently called ἀγκυλοβλέφαρος in Greek; but that is not found anywhere in the surviving Greek literature.[19]

Clearly, Greek compounds, which were much more frequently used in medicine than in Platonic or Aristotelian philosophy and science, often defied a one-word Latin translation. As the brief list shows, the explanatory translation may consist of two or three words, but occasionally even of an entire sentence. Occasionally, Greek terminology is not explained at all; Celsus obviously expects the reader to be familiar with these Greek names:

- is morbus est quem ἐλεφαντίασιν Graeci vocant (III.25.1, p. 141),
- morbum hunc χολέραν Graeci nominarunt (IV.18.1, p. 171–172).

In both these cases, we still use the Greek word for these diseases in modern languages such as English. Very rarely, Celsus apparently tries to coin a new term himself, as for the zygomatic bone (VIII.1.7, p. 364; English uses the Greek term!):

os [...] iugale appellari potest, ab eadem similitudine, a qua id Graeci zygodes appellant.
'it could be called the "yoke bone" by the same similarity as the Greeks call it zygomatic.'

Listing the Georges entries which quote Celsus but none of the authors before him and of his century[20] yields some 119 lemmata. Many of them are diminutives (18, e.g. *cicatricula*), which were typical for the spoken language,[21] but even more (57 in total) are formed with prefixes: *ad-* (2), *circum-* (4), *co(n)-* (5), *de-* (1), *ex-* (3), *in-* (6), *in- privativum* (5), *per-* (6), *prae-* (1), *sub-* (11), *subter-* (1), *super-* (12). There are also quite a lot of derived adjectives (16, e.g. *auricularius*), and especially many denoting nuances of colours. Rather less common are nouns formed with suffixes (*-tio* (5), *-mentum* (2), *-or* (2)) and derived verbs (*febrio, -ire; hebetesco, -ere; teneresco, -ere*). Only very few more specifically medical terms remain: *agrimonia* ('agrimony (a medicinal plant)'), *delirium* ('madness, delirium'), *gibbus* ('hunched, humped'), *hernia* ('rupture, hernia'), *scrotum* ('scrotum'), *simila* ('the finest wheat flour'). A list of the 42 lemmata Georges mentions exclusively for Celsus (underlined ones contain Greek parts) will give an impression of the rarer words not picked up by other writers:

agrimonia N; *cicatricula* N; *circumaperio, -ire* V; *coaestimo, -are* V; *excisorius* ADJ; *exspumo, -are* V; *extorreo, -ere* V; *febrio, -ire* V; *felinus* ADJ; *frictio, -onis* N; *gibbus* ADJ; *inalbesco, -ere*

19 As checked in in the online *TLG* (12 December 2018) and LSJ.
20 For the first century AD, I removed entries quoting Columella, Lucan, Quintilian, both Senecas, Suetonius, and Pliny the Elder.
21 See Hofmann (1978: 139–141).

> V; *inalgesco, -ere* V; *lanula* N; *manubriolum* N; *medullosus* ADJ; *murtaceus* ADJ; *percrassus* ADJ; *perliquidus* ADJ; *perpallidus* ADJ; *pyxidicula* N; *scrotum* N; *semicirculatus* ADJ; *sesquicyathus* N; *squamula* N; *subasper* ADJ; *subausterus* ADJ; *subcaeruleus* ADJ; *subcruentus* ADJ; *subhumidus* ADJ; *subrotundus* ADJ; *subruber* ADJ; *subsimilis* ADJ; *subterago, -ere* V; *superaccommodo, -are* V; *superdeligo, -are* V; *superincīdo, -ere* V; *superincresco, -ere* V; *superinfundo, -ere* V; *suppallidus* ADJ; *teneresco, -ere* V; *trunculus* N.

Unexpectedly, adjectives (18) and verbs (14) are more common than nouns (10). There are no uninflected words in the list. Most of these few words will not be new coinings but rather happen not to be preserved in earlier texts; it would seem that Celsus hardly, or not at all, coined new words.[22] Practising Latin physicians in Antiquity will have used Greek terms when no Latin ones were at hand. Patients who knew no Greek may even have been impressed by the educated doctor. Commonly used words in special, technical meanings are, of course, not so easily extracted automatically from a text, but they seem to be more common: for instance, Celsus uses *ductio* ('purging') or *acutus* ('acute (disease)').

Isidore of Seville (ca. 560–636) has already been treated as an encyclopaedist above (chap. 9 §7).[23] Although book IV of his *Etymologiae*, entitled *De medicina,* is not strictly speaking a medical work, as it is interested primarily in the formation of the words used in medicine, it may still be usable as an indicator of medical Latin vocabulary in his time. He explains the following 101 medical terms, which provide good examples of rare terms in the text (in brackets in classical orthography, again underlined are words with Greek parts):

> *aforismus [aphorismus], alopicia, apoplexia, apostoma, artriticus, atrofia, branchos, cacexia, cancer, carbunculus, cardiaca, cataplasma, catapotia, cauculus [calculus], cephalea [cephalaea], chronia, cicatrix, clistere, colica, comitialis, coryza, coticula, creticos, diarria [diarrhoea], dictum, dinamidia [dynamidia], disinteria [dysenteria], electuarium [electarium], elefantiacus [elephantiacus], enchiridion, enpiis [empye], epilemsia [epilepsia], erisipela [erysipelas], febris, fleumon [phlegmon], frenesis [phrenesis], frenusculi, furunculus, haemoptois, hepaticus, hicteris [icteris], hydropis, ileos, incensum, inpetigo, lentigo, lepra, lienosis, lienteria, mania, medicina, melancholia, mirobalanum [myrobalanum], mortarium, nefresis [nephresis], nyctalmos, odor, [h]ordeolus, oscedo, papula, paralesis [paralysis], parotidae, peripleumonia, pestilentia, pharmacia, phlebotomum, phlegma, pleurisis, podagra, prognostica, prurigo, pustula, r[h]agadiae, raucedo, r[h]euma, sanguis, sanitas, sarcia, satiriasis [satyriasis], scabies, sciasis [ischias], scothomia [scotoma], serpedo, similaria, spasmus, stacten, stranguria, synanchis, syringio, tetanus, thymiama, tisis [phthisis], tussis, ulcus, unguenta, verrucae, ὀξέα, ὑδροφοβία.*

22 The same conclusion was reached by Brolén, *De elocutione*, p. 11.
23 Quoted still from the Lindsay edition;vol. 4 has not yet been published in the new Belles Lettres edition.

Only 34 of these are fully Latin words. Besides many medical technical terms, there are also some quite common ones such as *odor, sanitas,* or *sanguis*. Exclusively nouns are explained, many of them ending in *-a* or *-is*. Looking at the entire text (without the headings), 21 words are found that Georges does not list or mentions only for Isidore (classical spelling in brackets):

> *arteriasis* N; *brancias [branchias]* N; *cephalea [cephalaea]* N; *diaeticus* ADJ;[24] *dynamidia* N; *empiis [empye]* N; *fellicula* N *(translates χολέρα); frenusculus* N; *haemoptois, -idis* N; *inglutio, -ire* V; *impensatio* N; *inguinarius* ADJ; *larvaticus* ADJ *(varia lectio larvatio N); marciatum [martiatum]* N; *nyctalmus* N; *phlegmaticus* ADJ; *sarcia* N; *sarnam* N; *serpedo* N; *squamatio* N; *subcutaneus* ADJ.

These are 15 nouns, 5 adjectives, and 1 verb; one of these words is noted by Isidore as colloquial (*sarnam*). Not included in the list are words that Isidore invented exclusively for the sake of his etymologies (*A quasi B*), such as:

> *Et ulcus, quod olet, quasi olcus.*[25]
> 'And ulcer [*ulcus*], what smells [*olet*], as if one said *olcus*.'

In general, Late Antiquity had a freer approach to coining new words than the 'classical' period (ca. 100 BC–ca. AD 100).[26] In the case of Isidore, there are indeed quite a few, mostly nominal, derivations, but he does not form new genuine compounds.

Gariopontus (d. ca. 1050) has also been mentioned in passing above (chap. 9 §12). He is one of the early authors associated with the medical school at Salerno. His work *Passionarius* was very successful; there are some sixty-five known manuscripts.[27] This author used mediaeval medical texts often ultimately going back to late antique translations from Greek to compile his large work, for instance the texts known as *Aurelius* and *Esculapius* (Late Antiquity) and texts by Theodorus Priscianus (fourth century). Besides the manuscripts, there are also several early modern prints showing that the knowledge collected by Gariopontus did not seem to be perceived as outdated even five hundred years later.[28] His text is used as an example of early Salerno medicine before the influx of Arabic and

24 Quoting Celsus' text quoted above, but in Latin letters: *Sunt autem omni curationi species tres: primum genus diaeticum, secundum pharmaceuticum, tertium chirurgicum.*

25 Similarly: *pastulentia*, *piligmenta*, *squammies*.

26 See chap. 9 above, and further examples from Christian Latin in Blaise (1955: 15–16).

27 Eliza Glaze is preparing an edition. For now, see Glaze (2009) on the text.

28 e.g. the edition Gariopontus, *Passionarius* (1526). In 1576, the work was still printed in the florilegium *De febribus opus sane aureum, non magis utile, quam rei medicae profitentibus necessarium* (Venetiis: apud Gratiosum Perchacinum; https://archive.org/details/bub_gb_mG06v0J9yXgC).

Greek translations. The text is heavily dependent on late antique medical literature; its Latin is strongly influenced by it.

Bernardus de Gordonio (ca. 1258–ca. 1320) was a professor of medicine at the University of Montpellier, which was the leading school for medicine in his time besides Salerno. A text of his is used as an example of scholastic university medical Latin from the late thirteenth century. Very little is known about the author – basically, only what can be extracted from his many works. Chaucer mentions his name in a list of famous physicians (*Canterbury Tales,* ed. Skeat, line 434). According to Demaitre (1980), ten genuine works of his are known. The *Tractatus de crisi et de diebus creticis,* of which there is a recent critical edition, is used here. It treats the *scientia praedicendi* for many different diseases. Its editor, Guardo, notes that the treatise's language is very similar to that used at the school of Salerno and especially that of Constantinus Africanus (edition, p. 71).[29] It will be found that this text contains the most un-classical vocabulary among the sample; the author occasionally also uses Arabic loanwords.

In early modern times, medical writers become more or less influenced by humanist language. Once Greek medicine was fully assimilated, Arabic terms disappear more and more from Latin medical texts (with a few exceptions that often live on in our modern languages: *alcohol, camphora, elixir, sirupus,* ...).[30] But in the time of the humanist movement, there were also some physicians who sought to 'improve' their style and language more radically and write more classicist Latin. The best known such author is Andreas Vesalius (treated in chap. 13 §4 above). Only book one of his major work *De humani corporis fabrica* was used in this study, and only Latin words were considered (Vesalius tends to compare Greek and Hebrew names to the Latin ones he actually uses). His style is definitely classicist and his vocabulary richer than usual (most lemmata per sample); the use of words not attested in Georges is rare, but even a classicist cannot always avoid some new words in fields like this one. Sometimes they are Latin names for parts of the body not attested in Antiquity (such as *mammillares*) or derivations (about which more in the next section), such as *arterialis, arteriola;* and sometimes words that are now very inconspicuous and common, such as *cuneiformis,* are found in Vesalius (no other occurrences in Corpus Corporum). Many of these words are nouns. These new terms, however, tend to be constructed in a straightforward Greek or Latin way that might not have surprised, say, Cicero.

29 Unfortunately, Guardo compares this author's Latin to classical Ciceronian Latin, not to Mediaeval Latin.
30 On this process, see Hasse (2016).

Daniel Sennert (1572–1637) was a renowned Lutheran physician in Wittenberg, whose speciality was iatrochemistry.[31] His voluminous *Institutiones medicinae* written in 1520 in five volumes is only one of his many works.[32] Sennert's vocabulary already reminds the reader of modern medical Latin terminology. Although Sennert's Latin also avoids what was perceived as typically mediaeval (Arabic words, 'scholastic' syntax, mediaeval spelling), his Latin is much more pragmatic than Vesalius'. There are hundreds of words not found in the Georges dictionary; many of them are *graeca*, but here are some purely Latin ones: *alimentalis, alimentaris, alimentosus, cinamomum, circumgyratio, deglutitio, flatulentia, flatulentus, flatuosus, putredinalis, putrescibilis, scorbutum, serositas, serosus,* besides many colour adjectives differentiated with *sub-* (as already in Celsus). A few terms are explicitly described as colloquial:[33] *lancetta, menstrua alba, spelta*. A rare example of a term derived from a vernacular language is *scorbutus* from French, which in turn was derived from Middle Low German *schorbûk* (according to the *OED*). Of course, there are also many names of medicinal plants and substances, such as *equisetum, tormentilla, veronica, zedoaria*. Sometimes adjectives turn into nouns: *caeliaca* (*passio*) ('an intestinal disease, coeliac disease').[34] Many of these terms and suffixes are still in use today in medical science, despite the fact that modern medicine does not use Latin any longer. Sennert's free use of new terms put together from Greek and Latin constituent parts, especially with the use of suffixes and prefixes, seems to have been the standard approach for early modern physicians.[35] Later physicians such as Francis Home in his *Principia medicinae* (4th ed., Amstelodami, 1775) still use a language similar to the one found in Sennert, although there seem to be rather more new technical terms; barely Latinised Greek compounds (such as *ophistotonus*) are even more common, as are terms

31 On this author, see online at http://galileo.rice.edu/Catalog/NewFiles/sennert.html.
32 There is an online scan of the book at http://www.uni-mannheim.de/mateo/camenaref/sennert2.html.
33 A lemmatised query in Corpus Corporum with 'vulgus (voco|appello)' finds 54 instances.
34 He defines (the term is not in Corpus Corporum before him): *A lienteria saltem secundum magis et minus differt affectio seu passio caeliaca dicta, quae est nimis celer cibi et potus parum mutatorum deiectio, seu excretio alui praeternaturalis, in qua chylus adhuc crudus et imperfecte coctus deiicitur* ('The condition or disease called "coeliac" differs from lientery in quantity, it is a too fast expulsion in hardly changed form of food and drink, or the excretion by an unnatural stomach in which [digestive] liquid is ejected that is still crude and not well digested'; *Institutiones medicinae* III, aphor. 22, p. 302).
35 A few examples from another author, the anatomist Julius Caesar Arantius (1529/1530–1589), *De humano foetu liber* (Lugduni Batavorum, 1664) confirm this: *venarum et arteriarum canaliculi* (p. 17), *uterinum jecor* (i.e. the placenta; p. 19), *sanguificatio* (genesis of blood in the developing embryo; p. 19).

consisting of two Latin words (*scarlatina febris*). They are often descriptive and need no explanation (*procidentia ani*). A physician from the nineteenth century was chosen as the last Latin author to be considered in the sample here.

Franz von Bene the Elder (fl. 1818) was a Hungarian medical doctor who worked in Budapest. He was *senior* at the medical faculty.[36] His five-volume work *Elementa medicinae practicae* (Pest, 1833–1834) was published posthumously by his son of the same name. Von Bene the elder also wrote a short treatise, *Brevis doctrina de vaccina* (Buda, 1818), about the recent technique of vaccination against smallpox using fluid from cowpox pustules (*variolae vaccinae*), which explains the English and Romance name 'vaccination' ('cowing'). Toward the middle of the nineteenth century, it was no longer common in most of Europe to publish medical treatises in Latin. This was only continued in countries in which none of the major emerging vernaculars was in use, such as Hungary. The *Elementa* treat in this order: *Doctrina de febribus*, *De inflammatione generatim*, *Inflammationes in specie* (among which: *encephalitis*, *myelitis*, *otitis*, *glossitis*, *diaphragmitis*, all words absent from Latin dictionaries and Corpus Corporum), *Efflorescentiae cutaneae* (among which: *lupus*, *erysipelas*, *framboesia*),[37] *Excretiones morbosae*, *Retentiones*, *Cachexiae*, *Nevroses* (many diseases ending in *-algia*, further split into *dolores*, *spasmi*, *debilitates*, *vesaniae*). A glance at the detailed index shows that here for the first time in this survey proper names are in use, for instance *morbus maculosus Werlholfii*, or *methodus Weinholdii* against syphilis. But this was still very much the exception.

In order to provide a more tangible example of this final stage of medical Latin, a random excerpt of this hardly known text is provided here. Linguistically interesting features are highlighted as in chapter 19 §4 above. The quoted text is from *Elementa medicinae practicae*, vol. 1, §205, Pest edition, pp. 267–268; it treats inflammations and their causes.

Ad naturam inflammationis individualem definiendam collectio symptomatum sola haud sufficit, sed causae etiam erui debent. In omni QUIDEM *homine inflammatio evolvi potest, aliqui* TAMEN *dispositionem eminentiorem possident, vel ad omnem inflammationem, vel ad unam alteramve in specie, ~~quae~~ dispositio saepe haereditate acquisita, congenita, saepe per influxus diversos generata est. In genere sexus virilis corripitur frequentius inflammationibus, licet nec in sexu foemineo rarus sit morbus; ~~qui~~ temperamento cholerico-sanguin eo gaudent, facilius inflammationem experiuntur, quam temperamento*

A group of symptoms alone does not suffice to define the individual nature of an inflammation; instead, the causes also need to be elicited. An inflammation may develop in any human being, but some have a more conspicuous disposition either for all inflammations or for one or the other especially. This disposition is often hereditary, inborn, often caused by diverse influences. In general, the male sex is more often attacked by inflammation, although the disease is not rare among the female sex either. Those who enjoy a choleric-sanguine temperament experience inflam-

36 Callisen (1830–1845: 26:233).

37 Derived from French *framboise* ('strawberry').

phlegmatico ac melancholico praediti. Relate ad vitae periodos inflammationes frequentissimae sunt in aetate iuvenili ac virili, non tamen rarae in aetate infantili, imprimis tempore dentitionis, facile evolvitur meningitis; aetate puerili infesta est tracheitis; aetas iuvenilis pronior est in peripneumoniam et carditidem; in muliere metritides, in viro ac sene inflammationes viscerum abdominalium facile evolvuntur. In inflammationem perpessis generatur per eam dispositio ad eamdem inflammationem. Causae excitantes inflammationum sunt multiplices inter ~~quas~~ frequentissime accusatur influxus atmosphaerae noxius; subinde calore ***suo*** *exaltato sive per radios solis, sive per artem, provocat non tantum cutis ambustionem, sed et alias phlegmasias graves. Longe frequentius tamen excitatur inflammatio per refrigerium, ~~cuius~~ actione non tantum pernio, sed etiam inflammationes diversae internae producuntur, imprimis si corpus antea incaluerit et in sudore constitutum fuerit; ideo inflammationes topicae frequentissimae quidem sunt hyeme, sed non rarae etiam aestate et sub zona torrida, dum per pluvias, aut per ventum frigidum, temperatura aeris notabiliter imminuitur; subinde mutatio partium constitutivarum, accumulatio excessiva oxygenii, praesentia vaporum diversorum irritantium vegetabilium aut mineralium, vel constitutio peculiaris atmosphaerae provocat inflammationem topicam.*

mations more easily than those endowed with a phlegmatic or melancholic one. In relation to the periods of life, inflammations are most frequent in juvenile and adult age, but they are not rare in infant age; especially during dentition, meningitis develops easily. Puerile age is pestered by tracheitis, juvenile age is more prone to peripneumonia and carditis. Among women metritis, among men and old men inflammations of the abdominal viscera easily develop. Among sufferers of an inflammation, a disposition is produced by it for the same inflammation.

The causes of inflammations are multiple, among them noxious atmospheric influx is most often held responsible, frequently by its high temperature or by the Sun's radiation, or artificially it provokes not only a burn of the skin but also other grave types of burns under the skin. But most frequently, inflammation is caused by cold, whose action produces not only frostbite but also various internal inflammations, first of all if the body is heated up sweating previously. Therefore, topical inflammations are most frequent in winter, but not rare either in summer and in torrid zones when the temperature of the air is reduced noticeably by rain or cold wind. Frequently, a change in the constituting parts, an accumulation of oxygen, of diverse irritating vegetable and mineral vapours, or a particular constitution of the atmosphere provokes a topical inflammation.

The Latin looks very technical, especially the vocabulary, which is often formed with suffixes (but besides von Bene, only Gordonius uses suffixes profusely in our sample). The plain, unrhetorical syntax resembles that of Pliny: the content looks like a list. As can be seen, the modern Latin-based medical terminology is already very much developed in this text, and many of the technical terms are still identical in medical English today; exceptions, such as terms from humoral pathology, are due to changes in the scientific *Denkstil*.

§4 In order to achieve a more systematic approach to how novel vocabulary typically looks in these seven authors, a list of lemmata not known to the Perseus PoS tagger or to Georges was generated.[38] In order to use the same amount of text for

38 Normal Greek words (that can be found in LSJ) and orthographic variants (such as Isidore's *apostoma* for *apostema*) are not listed. The Perseus word-list 'latin-analyses.txt' from Diogenes 3.2 (https://d.iogen.es/d) was used. It contains 270,227 entries.

all of them, only the first 3,389 words (the length of the shortest text) were used. Lemmata are given in classical orthography, regardless of the edition's orthographic choices. The PoS is added, including the inflection (if unclear); words with Greek parts are, again, underlined.

Celsus, *De medicina*: (none; also none that Georges mentions only for him).

Isidore:[39] *arteriasis* N; *branchias* N; *cephalaea* N; *diaeticus* ADJ; *dynamidia* N; *empye* N; *fellicula* N; *frenusculus* N; *haemoptois*, *-idis* N; *inglutio*, *-ire* V; *impensatio* N; *inguinarius* ADJ; *larvaticus* ADJ; *marciatum* N; *nyctalmus* N; *phlegmaticus* ADJ; *sarcia* N; *sarnam* N; *serpedo* N; *squamies* N; *squamatio* N; *subcutaneus* ADJ.

Gariopontus:[40] *causis* N; *confatigo* V; *constrictorius* N; *diaquilon* N; *diasampsucum* N; *embrocho* V; *emphraxis* N; *encausis* N; *epilampadium* N; *epiplocen* N; *eventatio* N; *fenigrecum* N; *lixoperitia* N; *omphacomel* N; *oxyrodinum* N; *paracope* N; *pericausis* N; *pericauson* N; *plethoricus* ADJ; *ruboratus* ADJ; *squibala* N; *singultatio* N.

Bernardus de Gordonio:[41] *acrocornis*, *-idis* N; *alitatio* N; *appodio* V; *armenicus* ADJ; *bor[r]ago*, *-inis* N; *brodium* N; *camphora* N; *cassiefistula* N; *causo[n]*, *-nis* N; *colligantia* N; *defoedatio*, *-nis* N; *diaeto*, *-are* V; *diabor[r]ago*, *-inis* N; *diasena* N; *grampa* N; *hiera* N; *lipparia* N; *mollificatio* N; *morphea* N; *nenufare* N; *opilo*, *-are* V; *hordeatus* ADJ; *paroxysmus* N; *paulatinus* ADJ; *penetrativus* ADJ; *pernecabilis* ADJ; *pungitivus* ADJ; *scrofula* N; *serpigo*, *-inis* N; *situo*, *-are* V; *subet* N; *subtiliativus* ADJ; *supercalefio* V; *syrupus* N; *tuellus* N; *uritivus* ADJ; *ictertitia* N; *zimia* N; *zuccara* N.

Andreas Vesalius: *confarcino* V; *consodalis* N; *curativus* ADJ; *oscitantia* N; *praemiolum* N.

Daniel Sennert: *bezoardicus* ADJ; *cagastricus* ADJ; *chymia* N; *chymiatrus* N; *chymica* N; [*acetum*] *destillarum* N; *hecticus* ADJ; *iatrochymicus* N; *rebisoleum* ADJ.

Franz von Bene: *asphycticus* ADJ; *bagdadensis* ADJ; *catarrhalis* ADJ; *classificatio* N; *contrastimulus* N; *convulsivus* ADJ; *epilogismus* N; *gastricus* ADJ; *homoeopathica* N; *humoralis* ADJ; *icterodes* ADJ; *incitabilitas*, *-tis* N; *inflammatorius* ADJ; *mesmerismus* N; *nosiologicus* ADJ; *nosologia* N; *ophthalmoiatria* N; *pestilentialis* ADJ; *pharmacologia* N; *physiologicus* ADJ; *rheumaticus* ADJ; *sphacelus* N; *variola* N; *zelosus* ADJ; *zooiatria* N.

39 See this same list already above, with some comments.

40 Quite a few words Gariopontus uses are only known to Georges from Caelius Aurelianus or Theodorus Priscianus, whose texts were among Gariopontus' sources.

41 More information about most of these words can be found in Guardo's glossary to the edition.

Arranging the above in a table according to PoS yields table 24.

Table 24: Non-classical words and their PoS in the first 3,389 words of the seven texts studied.

Author	Time	N	ADJ	V	*Aptota*	Total	Of which Greek
Celsus	ca. 50	0	0	0	0	0	0
Isidore	ca. 620	16	5	1	0	22	10 (45 %)
Gariopontus	ca. 1050	18	2	2	0	22	15 (68 %)
Bernardus	ca. 1300	26	8	5	0	39	5 (13 %)
Vesalius	1543	3	1	1	0	5	0 (0 %)
Sennert	1628	3	6	0	0	9	5 (55 %)
von Bene	1833	12	13	0	0	25	15 (60 %)
Total		78	35	9	0	122	50 (43 %)

The low numbers in Vesalius may be expected, but those in Sennert are surprising; they are not an artefact, although he speaks at the beginning of his work about the nature of medicine, which may be expected to use a different register (dedications and *praefationes* were not included in our counts).[42] The table shows that Bernardus uses non-classical words most commonly; Vesalius and Sennert in early modern times the least; Isidore, Gariopontus, von Bene quite a lot. Only Bernardus uses words that are not derived from Greek or Latin, namely Arabic ones (*nenufare, subet, syrupus, zuccara*).[43] All in all, it would seem that the tendency to use new words in medicine continued to rise, despite a little dip due to humanist classicism. The more lasting influence from this movement may lie in the fact that non-Graeco-Latin words ('barbaric' ones, according to humanists) were henceforth shunned and that classical rules for forming new words were more strictly followed. An unexpected observation is that modern authors use more unusual adjectives than nouns. No new uninflected words were found in the sample, which would seem to be a normal feature of many languages of science (see chap. 18 §4).

42 The beginning of book III was also counted to rule this possibility out. Only slightly more words were found (11 words): *bitus*, *-us* N; *carnosus* ADJ; *dissimilaris* ADJ; *excrementitius* ADJ; *insalubritas* N; *laeditura* N; *morbificus* ADJ; *pathognomonicus* ADJ; *semioticus* ADJ; *supervenientia* N; *vagantia* N.

43 The case of Vesalius' Hebrew words is different: they are just mentioned as translations, not used in the text.

Contemporary post-Latin terminology

§5 In the twentieth and twenty-first centuries, Latin is practically not used for medical publications any more; a science of such practical importance obviously produced vernacular publications early on,[44] and only theoreticians strove to remain a closed circle and wrote Latin. Nonetheless, most of the vocabulary touched upon here is still very much in use in medicine today. Many diseases, drugs, and methods still bear the traditional Graeco-Latin names in medical English or German. In general, it can be observed that names already in use in the *corpus hippocraticum* have often remained in use (such as *ischias* or *gangraena*). Such Greek terminology is often not explained by the Latin authors, even if the word has a Latin homophone, such as *coma* (Greek 'coma', Latin 'hair').[45] A look at how new medical phenomena are named today, in the post-Latin age, shows that in general there seems to be more freedom in the choice of names – a postmodern 'anything goes' seems to apply, similarly to what was observed above for the human sciences. Correctly formed Graeco-Latin coinings are becoming rarer, but are still occasionally proposed for new phenomena. Some examples, with the year of first use according to the *OED*:

- *encephalomyelitis* (from 1906),
- *endosymbiosis* (from 1932),
- *immunoglobulin* (from 1953).

Proper names (of the discoverer or place of discovery) for new phenomena now seem to be much more common:

- Chagas disease (1909, first described by Dr Carlos Chagas),
- Alzheimer's disease (from 1911, after Dr Alois Alzheimer),
- Ebola virus (from 1976, after the Ebola river in Congo).

As descriptive names have tended to become longer, abbreviations/acronyms have become common (something not observed in the Latin texts). The abbreviations have often entered routine usage. Besides, there are 'anything goes' names with a purely accidental connection to the phenomenon in question:

- 'Acquired immune deficiency syndrome' (usually just 'AIDS', from 1982).
- 'Severe acute respiratory syndrome' (usually just 'SARS', from 2003).
- 'Sin nombre virus' (from 1993, Spanish for 'without name'; causes the hantavirus cardiopulmonary syndrome).

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44 Already early on, there were dictionaries for medical terms in the vernacular tongues, e.g. Woyt (1696) for German.

45 Sennert II.3.1.7, p. 313, explains the word; Home, *Principia*, *p*. 222, does not.

- ‘Midichloria’, a pathogenic, tick-borne bacterium named after a creature in the *Star Wars* TV series (2004).
- ‘Gene’, a word invented by the Danish botanist Wilhelm Johannsen in 1909, vaguely reminiscent of γένος. Jesuit authors formulated this concept in correct Latin as *determinantia* (see §2 above).
- ‘Clusters of differentiation’ (usually abbreviated ‘CD’) are cell adhesion molecules in immunology. They are simply numbered sequentially – for humans there are now (2016) 371 numbers – despite their very diverse functions; this makes learning them very unintuitive for students (see fig. 47).
- ‘Toll-like receptors’, a class of proteins important in the immune system, are named after the *Drosophila* gene ‘toll’; its German discoverer thought it was *toll* (‘awesome’). Similar cases abound. One more: ‘spaetzle’ is the name of a protein of *Drosophila melanogaster* (named after the Swabian dish) which, apparently, produces larvae resembling *Spätzle*. Its precursor is called prospaetzle.
- Sometimes new terms can even consist of affixes only, such as ‘polyoma’ (cf. Gottlieb & Villarreal 2001), referring to the ability of viruses to produce multiple (πολύ) tumours (-*oma*) – a word without a root.

Clearly, this modern proliferation of terminology loses the mnemotechnical advantages the old Graeco-Latin system had. Today, medical students have to learn by heart countless abbreviations and many names without any relation to what is named (‘sin nombre virus’); whereas in the past, after they had mastered some Latin and Greek, much of the terminology became more or less automatically understandable. It is to be hoped that molecular biology terminology will be improved at some point, as happened in organic chemistry through IUPAC in the twentieth century. This modern ‘anything goes’ approach can be traced back in principle at least to the late eighteenth century, for instance the entomologist Johann Christian Fabricius (1745–1808) said (*Entomologia systematica,* Hafniae, 1792, 1:x):

> Nomina *valent uti nummi praetio certo, determinato. Optima sunt, quae omnino nil significant.*
> ‘*Names* have a certain, determined value like money. Those are the best that mean nothing whatsoever.’

His teacher Linnaeus had already held similar views. But in practice such an approach becomes common only in vernacular science in the nineteenth and twentieth centuries.

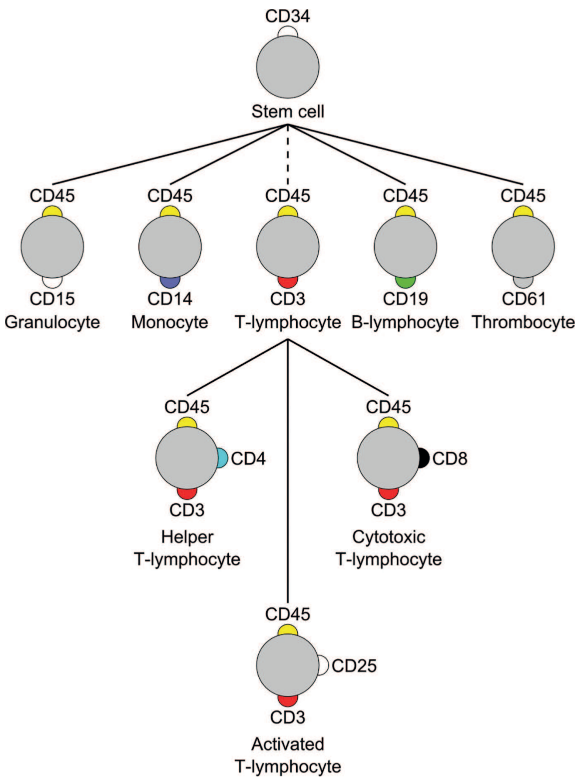

Fig. 47: Example of 'CDs'. Source: https://commons.wikimedia.org/w/index.php?curid=8797123 (image by user Lokal Profil, https://creativecommons.org/licenses/by-sa/2.5).

§6 Nonetheless, some Latin systems of nomenclature are still in use. From early modern times onward (at least since Sennert), the suffix -*itis* has been used to denote an inflammation[46] of the organ in the head of the compound, such as *rhachitis* (ῥαχῖτης) or *hepatitis* (ἡπατῖτις). Originally, this Greek suffix denoted similarity, so semantically a 'liver inflammation' grew out of Greek 'like the liver'. This suffix is now freely combinable in this function (*diaphragmitis, paraphrenitis, …*). Adjective-forming suffixes are also very common. A German online script for medical students explains the following ones (including example words derived from *arteria*; I add English translations in parentheses):[47]

46 Home, *Principia*, p. 140, explains the suffix as *inflammatio*.
47 'Medizinische Terminologie' by the Charité Berlin: https://medizingeschichte.charite.de/fileadmin/user_upload/microsites/m_cc01/medizingeschichte/Lehre/Skript_Medizinische_Fachsprache_Modellstudiengang_Charit%C3%A9_Auflage_2_2015.pdf.

- *arteria*, *ae* f. = die Schlagader ('artery'),
- *arterialis*, *is*, *e* (die Schlagader betreffend) ('concerning the artery'),
- *arteriosus*, *a*, *um* (schlagadernreich) ('rich in arteries'),
- *arteriola*, *ae* f. (die kleine Schlagader) ('small artery'),
- Arteriosklerose (chronisch degenerative Verhärtung von Schlagadern) ('chronic, degenerative hardening of arteries').

In contrast to *-itis,* the normal Latin functions of the three suffices *-alis, -osus, -olus* are still in use here. They were already used systematically by Sennert and to some extent Vesalius (despite the fact that the resulting words may not have existed in Classical Antiquity). The last-mentioned example shows another type of new word produced by Greek compounding. There are many 'frozen' Greek words primarily used as suffixes in medical language today. Besides *-sclerosis* (σκλήρωσις, 'hardening'), we can mention *-algia* (ἄλγος, 'pain'; e.g. 'gastralgy', 'neuralgy') to denote pain, *-ectomia* (ἐκτομή, 'cutting away'; as in 'appendicectomy', 'vasectomy') to denote the surgical removal or cutting of something, or *-mania* (μανία, 'madness'; as in 'nymphomania', 'hippomania') to denote a pathological engagement with something. Thus, a physician does not have to learn how arthralgy differs from arthritis; he only needs to know the Latin medical suffixes. In English today such suffixes are occasionally also used with non-Latin heads: 'seizurogenic'[48] means 'something that induces seizures'.

Dirckx (1983) offers a survey of modern English medical terminology and its roots which is full of instructive and often amusing examples. On the whole, it is almost exclusively long-known diseases and body parts that bear English names. Discoveries of modern, scientific medicine tend to bear Latin or Greek names, as do parts of the body that are hard to observe and thus did not have a common English non-scientific name. Although many of the recently coined Latin and Greek names are not well formed according to classical rules – such as the Graeco-Latin 'hyper-tension' – they have the advantages of being capable of international use and of being unambiguous: exactly the same reasons that kept Latin as a whole alive in the sciences much longer than in many other areas of life. Since knowledge of the classical languages among physicians has almost disappeared, word-material from various languages is now quite freely combined, such as 'beet-uria', 'alkal-osis', 'acetyl-choline', 'vin-yl' (Dirckx 1983: 106), but there is still a clear domination of morphemes from Greek and Latin. There is, however, also some danger of misuse due to 'a craze to attach labels ([…] *cardioselective*), an obsession to manufacture jargon (*atraumatic normosis*), or a weakness for no-

48 Not yet in *OED*, but quite common according to an online search.

velty (*pseudopseudohypoparathyroidism*), euphemism (*chemical dependence*), or circumlocution (*erectile dysfunction*)'; besides, '[i]gnorance of English has led to the creation of *fecundability* and *obtundation*, even though *fecundity* and *obtusion* are already in the language' (Dirckx 1983: 159). Dirckx exhorted his colleagues to use 'more intelligence and foresight' in novel coinings, and 'at least try to preserve established phonetic, semantic, and structural traditions, and above all, exercise a little restraint' (1983: 195). At a time of strongly reduced Latin teaching at UK schools, this exhortation will likely be of little avail.

In chemistry, such Graeco-Latin nomenclature is much further developed, and much more detached from its Latin roots; Pörksen rightly called it a 'Musterbeispiel einer internationalen, selbsterklärenden, durchsichtigen Nomenklatur' ('prime example of an international, self-explanatory, transparent nomenclature'; 1984–1985: 94). This chapter therefore concludes with a look at an example from chemistry.

Trends in new nomenclature?

§7 In order to return to the question posed at the beginning of this chapter, it may be instructive to have a look at another, related, example that has been studied very thoroughly: the naming of chemical elements.[49] Of course, these elements were only identified as 'elements' by post-Lavoisier chemistry; before then they were just 'substances', but this matters little for the present purposes. Here some examples grouped by the way of naming and the time of their first naming.[50]

- (i) Elements known since pre-scientific times bear popular, 'trivial' names: *ferrum, argentum, aurum*.
- (ii) Elements discovered in Antiquity tend to bear understandable, transparent ('Democritean') names, such as *hydrargyrum, auripigmentum* (the Latin name for arsenic (ore)).[51]
- (iii) The same holds true for elements discovered in the Middle Ages and early modern times, although sometimes the motive behind the name proved wrong: *antimonium*,[52] *phosphorus* (Henning Brand distilled it from urine in 1669 and called it *phosphorus igneus*), *hydrogenium* (christened as *hydrogène*

49 See the instructive list at https://en.wikipedia.org/wiki/Timeline_of_chemical_element_discoveries.

50 Of course, these two principles do not always fit together. The reader will spot some elements that were not named typically.

51 Cf. Isidore, *Etymologiae* XIX.17.12, ed. Rodríguez Pantoja, p. 133.

52 Since Constantinus Africanus; the origin is debated, but it is certainly meant to sound Greek.

by Lavoisier in 1783), *oxygenium* (*oxygène*, Lavoisier in 1777; mistaken name: acids are characterised by hydrogen ions, not oxygen).
- (iv) From the nineteenth century onward, after the place of discovery: ruthenium (1844, Russia), germanium (1886, Germany), francium (1939, France), californium (1950, California), moscovium (2010, Moscow); later (twentieth century) also after famous scientists: curium (1944, Marie Curie), einsteinium (1952, Albert Einstein), rutherfordium (1969, Ernest Rutherford).
- (v) From vernacular languages: cobalt (after German *Kobold*);[53] bismut (ca. 1660, etymology debated, but certainly not Graeco-Latin); platinum (named by Watson in 1750),[54] from *platina*, the Spanish diminutive of *plata* ('silver').

Despite these patterns, older methods of naming kept being used later on: lanthanum (1838) is indeed 'hidden' by being very rare, helium (1868) really does occur in significant amounts in the Sun, and the radioactive technetium (1937) really was artificially produced.

§8 As the samples studied here are small, we should not draw too far-reaching conclusions about the development of naming in medical Latin at this point, but most of the above results would seem to conform with what we would expect from earlier parts of this book. It can be summarised that medical Latin authors were at all times open to Greek words, especially compounds, but that other non-Latin words had a hard time being taken up in Latin medicine, except in Bernardus de Gordonio, whose time still relied to a large extent on Arabic translations of Greek texts and on Arabic sources. In his time, both Greek and Arabic were very distant languages that hardly anybody in the Latin West knew, and thus stood on near-equal footing. In Antiquity and early modern times, this was very different: educated people were expected to know Greek. Thus, Greek words in Latin texts were in these times seen rather as enrichment than as foreign elements.

The trend in all examples in this chapter was that in Antiquity, Latin authors tended to have what we called an 'Aristotelian' approach toward *nova verba*. In contrast, the Middle Ages and early modern times followed a more 'Democritean'

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53 Vicipaedia explains: *Verbum 'cobaltum' deductum est a verbo germanico Kobold, quod manem malum significat, ita appellatum a metallicis qui in fodinis laboraverunt, quia veneficium fuit et aerumnas multas fecit in aerem elementorum aliorum effodendo, ut qualitatem eorum diminuit* ('The word "cobalt" is deduced from the German word *Kobold*, which means "evil spirit"; it was called thus by the mineworkers who worked in the mines because it was poisonous and caused much distress in the air when other elements were to be dug up, as it diminished their quality'; https://la.wikipedia.org/wiki/Cobaltum, October 2017).

54 Details in Kopp (1843: 222–226).

one. The differences between the Middle Ages and modernity lay only in details in the formation of words. A greater change of approach happened exactly at the time when Latin fell out of common use in the sciences and people apparently stopped being held back by Latin stylistic concerns in medical science. But even von Bene in the nineteenth century still hardly uses personal names or other non-transparent coinings. During the entire Latin period, the approach to nomenclature and language in general was very different from that adopted in the twentieth century, as the few post-Latin examples above have shown. The Latin approach can be very well illustrated by Isidore's explanation of what an *etymologia* is – something quite different from our modern genetic 'etymologies' (*Etymologiae* I.29.1–5, ed. Lindsay; Latin text quoted in chap. 1 §9 above):

> 'Etymology is the origin of words, as the meaning of a verb or a noun is gathered from its explanation. [...] Its knowledge often has a necessary application in understanding [a word]. For, as you see whence a word stems, you will more easily understand its force. [...] Many [words] are also summoned from the speech of various peoples. Thus also their origin may be hard to discern.'

In the contemporary American approach to naming new medical phenomena, there can be no question of understanding the terms' 'semantic force'; they are often purely arbitrary. In fact, it looks as if a new agglutinative technical language could be emerging, using for its constituents more or less anything and allowing free combination, as 'polyoma' above showed. But this does still seem to be different in other sciences, for instance in the German human sciences, the *Geisteswissenschaften*, where the importance of abstract concepts that need to be expressed correctly is to this day higher; in German, the usual method is making use of compounds (which Latin, French, or English could hardly imitate),[55] whereas English has turned much more definitely to an 'anything goes' approach, as the examples in §2 illustrated.

One can look for internal, philosophical, language-normative views behind the differences observed. The rhetorical dislike of *nova verba* in Antiquity that we met above (chap. 8) stood in contrast to (as Stotz characterised scholastic Latin) a desire to have 'für jedwelches Gedachte einen unmittelbaren sprachlichen Zugriff durch ein Einzelwort' ('for any thought, immediate linguistic access through a single word'),[56] which would explain the more 'Democritean' approach in schol-

55 Good examples can be found in the works of Heidegger, Gadamer, or Luhmann. These authors often do not define their new compounds: they are taken to be understandable simply through their constituent parts and the context of their use – a very different approach than the American one current in the natural sciences.

56 Stotz (1996–2004: VI, §3.11 = vol. 2, p. 236).

asticism and the later Middle Ages. Now, interestingly, this scholastic desire did not seem to fall prey to the humanists, at least in the province of medical science, where authors used less unusual terms for some time but our last authors had no scruples at all. Only after the end of the general knowledge of and heavy training in Latin for all intellectuals did the current predicament, which allows much more freedom in naming novelty, come about – outside the Latin medium. Next, a step back is taken to see how Latin was able to render Greek science in comparison to other traditional languages of science. This will be done with another case study involving texts by Aristotle and Euclid.

22 How was Greek science imported into other languages?

§1 This chapter widens the view and compares several major traditional languages of science and their ways of expressing Greek scientific thought.[1] The focus will be on Latin, Sanskrit, and Arabic, but some scattered comments about Chinese are added as well. Greek translations into Latin happened in several stages and in at least four key periods, as was shown above (chap. 6 §2 with fig. 7).[2] As the Arabic language has a rather different structure than Greek and Latin (and Indo-European in general), it may come as a surprise how quickly the Arabs were able to assimilate Greek science and learning, subsequently producing significant advances in many fields.[3] The adoption began during the reign of Caliph Hārūn al-Rašīd (r. 786–809) and continued under his son al-Maʾmūn (r. 813–833). It was facilitated by Syriac precursor translations and by translators already used to dealing with scientific Greek. During this relatively short period, Arabic became a more or less standardised language of science and produced adepts who founded schools and traditions that were often to last for half a millennium. Indeed, the 'revolution' in Latin science in the twelfth century – which was considered above (chap. 11) – took some of its texts to translate from such Arabic sources.[4] Sanskrit has a rather similar structure to Greek, and could have quite effortlessly been used to translate scientific Greek; it largely relies on compounds to render technical terminology, as will be seen. Greek science does not seem to have been much translated into Sanskrit in Antiquity,[5] yet there was definitely contact that led among other things to a flourishing of mathematics around the fifth century AD (with authors such as Āryabhaṭa) in India, and later on, through Arabic mediation, in many other fields. Already in the time immediately after Alexander the Great, there were quite close relations between the two peoples.[6] King Aśoka (ca. 304–232) had Greek subjects in Kandahar, for he had edicts in-

1 An early stage of this chapter was presented at the congress 'Translation and Transmission in the Eastern Mediterranean 500 BC–1500 AD', Finnish Institute in Rome, September 2015.
2 See also Glucker & Burnett (2012), esp. Glucker (2012).
3 See Rashed (1997) as an introduction.
4 Some details about the Arabic language used in these translations can be found in Endress (1982–1992: 3:3–23) and in chap. 2 §6 above.
5 An exception is the astrological treatise *Yavanajātaka*, even exhibiting its Greek origin in the title (*yavana* = 'Greek'). It was edited by David Pingree in 1978. The text is a versification of a translation of a Greek text, apparently made in the third century AD. Pingree in his edition (p. 5) points out a likely process of Indian acculturation in this interesting text.
6 See Karttunen (1997); Stoneman (2019).

https://doi.org/10.1515/9783110745832-023

scribed in Greek (Schlumberger 1964). The case of Chinese is different again; direct contact between Graeco-Latin science and China seems to start as late as the Jesuit mission in China in the later sixteenth century, and then ran through the Latin medium.[7] The much older indirect access to Graeco-Roman ways of thinking through the Silk Road and through contact with Buddhist India (itself in contact with Greek culture) is hard to gauge. At any rate, it does not seem to have been lasting; for instance, the Chinese only learned that the Earth is spherical from the Jesuits.[8] More general questions of the relation of cultural spheres, language, and science will be taken up below (chap. 24).[9]

§2 In order to argue from concrete data, two influential Greek texts were chosen and their translations into these languages studied: the strongly formalised scientific language of geometry in Euclid's *Elementa,* and the less mathematical and more descriptive but logically structured kind of Greek in Aristotle's lectures (namely the *Poetica*, a work that scientifically studies parts of ancient Greek culture) are used as source material. These two works can stand for a 'hard' science and a human science text respectively, and will illustrate some differences between them. Both works were translated into all the languages with which we are concerned. In a first part, the translations of these two texts are briefly described in order to provide a background; then some peculiarities of the language of each of them are considered; finally, their way of translating is studied by looking at statistical values on the one hand and at some representative sentences and how they were rendered on the other.

Euclid's *Elementa* was an immensely successful book; it remained the standard geometry schoolbook for over two millennia.[10] It was studied, commented, and also translated many times. Figure 48 shows some of the translations into the languages studied here. In Antiquity the book quickly replaced all older manuals on geometry, which are now completely lost. The same fate might easily have happened to Euclid's original text as well, for Theon of Alexandria reworked it slightly around AD 360, correcting inconsistencies.[11] His revised text was the only one known until a single manuscript containing the older text was found in the

7 Jami & Delahaye (1993) study this cultural contact.

8 See Cullen (2001) on previous cosmological theories in China.

9 For help in mastering of the Arabic material, I am indebted to Benjamin Gleede and Emanuele Rovati. The Chinese was kindly checked by Wolfgang Behr.

10 This was still the case in the nineteenth century; cf. for instance Robert Potts's school translation of 1845.

11 A recent summary of geometry in Antiquity and the Early Middle Ages by Barbara Ferré can be found in her edition of Martianus Capella, *Les noces,* vol. 6, pp. ix–xxiv.

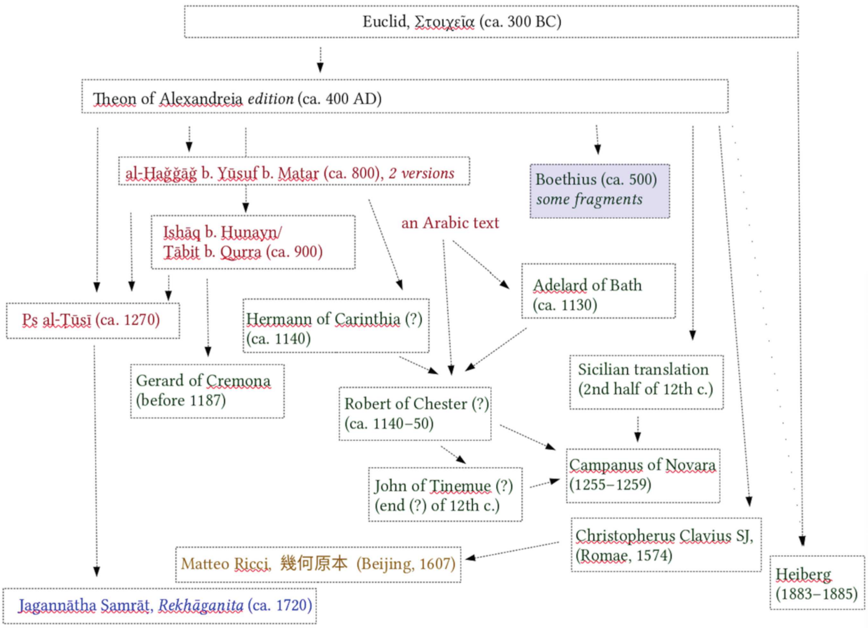

Fig. 48: Simplified schema of important translations and redactions of Euclid's *Elementa* into and in the languages considered here. Red: Arabic, green: Latin, blue: Sanskrit, brown: Chinese.

nineteenth century.[12] It is the basis of Heiberg's *editio maior*, which, incidentally, also contains a fresh Latin translation. The complicated situation of the early surviving Latin translations – that is, those from the twelfth century – was disentangled in many publications by Busard, who also edited them.[13] Only one of them was made directly from the Greek, the anonymous 'Sicilian translation' (already used above in the text sample in chap. 20); the others went through Arabic. The first known translation, apparently by Boethius, was lost early.[14] Besides quotations in other works, some fragments of books XI–XIII have survived on a palimpsest.[15] The few extant pre-twelfth-century Latin writers who wrote about geometry often just used the Greek terminology, as Martianus Capella does in his

12 Città del Vaticano, BAV, Vat. gr. 190, from the early ninth century.

13 For the disentanglement of the three 'Adelard' versions, see Clagett (1953); Burnett (1997b). On Adelard in general, see Burnett (1987).

14 But at least partial translations of the *Elementa* may have existed before Boethius, as indicated by the accurate knowledge of Martianus Capella (but he may have translated ad hoc from the Greek) of some parts of them (see Stahl 1971: 128–129). See further Stevens (2004).

15 Verona, Biblioteca Capitolare, XL (38), ed. Geymonat.

book VI (e.g. *monas*, *dyas*, *lineae cyclicae*, *lineae helicoides*). In order not to have to go too far into this apparently excessively Greek topic, Martianus spends much of the book *De geometria* on geography (§§567–805; geometry proper only §§706–724).

Fragments of a Syriac version translated from Ḥaǧǧāǧ's Arabic text are also extant.[16] Codex Leidensis 399,1 transmits an altered version of the second, shortened version by Ḥaǧǧāǧ (an epitome for Caliph Maʾmūn).[17] The Sanskrit translation also took a detour through Arabic. 'The first six books of Euclid's Elements, published in 1607, was the first substantial translation of a European text into Chinese.'[18] It was translated by the Jesuit missionary Matteo Ricci with the help of a Chinese collaborator. For many of these versions of the *Elementa*, there is a very useful synoptic online edition by Oslo University,[19] including a comparative article.[20] For an easier overview, the editions used are listed here, not in the bibliographies.

Greek
- Johan Ludvig Heiberg (ed.) (1883–1885): *Euclidis elementa*. Leipzig: Teubner. Includes a fresh Latin translation.
- Johann Wilhelm von Camerer & Karl Friedrich Hauber (eds) (1824–1825): *Euclidis Elementa graece et latine, commentariis instructa*. Berlin: Reimer. A print of the Theonine textus receptus.

Latin
- Mario Geymonat (ed.) (1964): *Euclidis latine facti fragmenta Veronensia*. Milan: Instituto Editoriale Cisalpino.
- Hubert Lambertus Ludovicus Busard (ed.) (1987): *The Mediaeval Latin Translation of Euclid's Elements Made Directly from the Greek*. Stuttgart: Steiner.
- Hubert Lambertus Ludovicus Busard (ed.) (1983): *The First Latin Translation of Euclid's Elements Commonly Ascribed to Adelard of Bath: Books I–VIII and Books X.36–XV.2*. Toronto: Pontifical Institute of Mediaeval Studies.

16 Furlani (1924).
17 The traditional account of the Arabic translations is presented here. According to it, Ṯābit made a new recension of Ishāq's revision of Ḥaǧǧāǧ's text. Brentjes (2018: 51) argues against the existence of this Ṯābit/Ishāq recension. Much remains unclear.
18 Quoted from the book cover of Engelfriet (1998).
19 https://www2.hf.uio.no/polyglotta/index.php?page=volume&vid=67 .
20 The article's authorship is not clear; its author may be Jens Braarvig. Unfortunately, he treats Mediaeval Latin as the product of incomplete knowledge of Classical Latin, and studies features such as *dico* + *quod* clauses, which are, of course, completely normal in Mediaeval Latin.

- Hubert Lambertus Ludovicus Busard (ed.) (2001): *Johannes de Tinemue's Redaction of Euclid's Elements, the So-Called Adelard III Version*. Stuttgart: Steiner.
- Hubert Lambertus Ludovicus Busard & Menso Folkerts (eds) (1992): *Robert of Chester's (?) Redaction of Euclid's Elements, the So-Called Adelard II Version*. Basle: Birkhäuser.
- Hubert Lambertus Ludovicus Busard (ed.) (1984): *The Latin Translation of the Arabic Version of Euclid's Elements Commonly Ascribed to Gerard of Cremona*. Leiden: Brill.
- Hubert Lambertus Ludovicus Busard (ed.) (1968):*The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?)*. Leiden: Brill.
- Hubert Lambertus Ludovicus Busard (ed.) (2005): *Campanus of Novara and Euclid's Elements*. Stuttgart: Steiner.[21]
- Christoph Clavius (ed.) (1574): *Euclidis Elementorum libri XV: Accessit XVI de solidorum regularium comparatione omnes perspectionis demonstrationibus, accuratisque scholiis illustrati*, 2 vols. Romae: Vincent. Accoltus; repr., Coloniae: expensis Ioh. Baptistae Ciotti, 1591. Reprint online at http://doi.org/10.3931/e-rara-15504.

Arabic[22]
- al-Ḥaǧǧāǧ b. Yūsuf b. Maṭar (1897–1932): *Euclidis Elementa ex interpretatione al-Hadschdschadschii cum commentariis al-Narizii, Arabice et Latine*, ed. Rasmus O. Besthorn & Johan Ludvig Heiberg, 4 vols. Copenhagen: Libraria Gyldendaliana. From Codex Leidensis 399,1; includes a Latin translation. Online at http://menadoc.bibliothek.uni-halle.de/ssg/content/structure/1201488.
- Ps-Naṣīraddīn al-Ṭūsī (d. 1274) (1594): *Kitāb taḥrīr uṣūl li-ʾUqlīdis* (Romae: ex typogr. Medicea; repr., Frankfurt: Institute for the History of Arabic-Islamic Science, 1997.

Sanskrit
- Jagannātha Samrāṭ (1901–1902): *The Rekhāgaṇita or Geometry in Sanskrit*, ed. Kamalāśaṅkara Prānāśaṅkara Trivedī (Bombay: Gov. Central Book Depot).[23]

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21 The complicated relationship between the Latin versions is disentangled by Busard in this edition, pp. 1–40.
22 Many texts are online at http://www.graeco-arabic-studies.org/texts.html. On the Arabic translations, see Brentjes (1994).
23 Online at http://jonathancrabtree.com/euclid/%0Aelements_book_VII_definitions_via_Jagannatha_Samrat_The_Rekhaganita.html.

Chinese

- Lǐ Mǎdòu 利瑪竇 [Matteo Ricci] and Xú Guāngqǐ 徐光啟 (1607): 幾何原本 *Jǐhé yuánběn*. Woodblock print Beijing 1607, kept in the Chinese National Library. Online: https://new.shuge.org/view/ji_he_yuan_ben. Books 1–6 only.[24]

§3 Aristotle's *Poetica*, on the other hand, was much less successful; indeed, its transmission was rather hazardous and only the first of originally two books is preserved (the lost one treated comedy). Tarán & Gutas have recently published an impressive *editio maior* taking into account the Semitic and Latin translations for the *constitutio textus* of the Greek text. A full stemma is provided (p. 159), which shows that the extant Greek and Moerbeke's close Latin translation[25] belong to a different primary branch than the Semitic translations. A more detailed genealogical tree of the Semitic translations is also provided (p. 110); from that Semitic branch stems another Latin translation by Hermannus Alemannus (thirteenth century – not used here). The surviving Arabic translation by Abū Bišr Mattā ibn Yūnus (d. 940) has been edited several times; Tkatsch's bilingual edition, which includs a fresh Latin translation, is used here. A contemporary Sanskrit translation is used here to study how this language deals with the content.[26] The editions used are as follows.

- Leonardo Tarán & Dimitri Gutas (eds) (2012): *Aristotle: Poetics; Editio Maior of the Greek Text with Historical Introductions and Philological Commentaries*. Leiden: Brill.
- Lorenzo Minio-Paluello (ed.) (1968): *De arte poetica: Translatio Guillelmi de Moerbeke post transcriptionem Ersae Valgimigli ab Aetio Franceschini revisam*, 2nd ed. Bruges: Desclée de Brouwer.
- Jaroslaus Tkatsch (ed.) (1928–1932): *Die arabische Übersetzung der Poetik des Aristoteles und die Grundlage der Kritik des griechischen Textes*, 2 vols. Vienna: Hölder-Pichler-Tempsky.
- Bharat Chandra Nath (2010): *Aristotle's Poetics: Sanskrit Translation and Critical Study*. Kolkata: Kolkata block and print.

24 On this translation, see Engelfriet (1998); Jami & Delahaye (1993).
25 Close, but 'Latin is not Greek: it has no article', as pointed out by Tarán & Gutas (edition, p. 137).
26 Its author does not mention from what text he translates, but as he does not seem to have mastered the Greek language, it is to be expected that he is translating from an unnamed English translation. Still, for our purposes – studying how content tends to be phrased – this is not too problematic (if we take it for granted that the English translation was able to make the original meaning clear).

Observations on the Greek of the two texts

§4 The first thing even a casual observer notes in the language of the *Elementa* is its uniform and formal organisation. Except for the definitions and axioms at the beginning of every new subject, the theorems always follow the same form: πρότασις (the formulation), ἔκθεσις (the 'setting out', a more detailed exposition introducing the letter nomenclature for the geometric objects in question), διορισμός (the 'definition' of how to reach the solution), κατασκευή (the geometric construction), ἀπόδειξις (the proof that the construction was correct, often by *reductio ad absurdum*), and συμπέρασμα (the 'conclusion', a restatement of the theorem, ending in the famous ὅπερ ἔδει δεῖξαι, our 'Q.E.D.').[27] Besides these six steps, there is a diagram which – contrary to modern maths books (where such diagrams only illustrate the problem and are not essential for the mathematical content) – often contains information that is not explicitly stated in the text, typically the relative position of the points to which letters are assigned. An example sentence, which will be studied in translation below, is Euclid, *Elementa* I, prop. 47 πρότασις (the Pythagorean Theorem):

> Ἐν τοῖς ὀρθογωνίοις τριγώνοις τὸ ἀπὸ τῆς τὴν ὀρθὴν γωνίαν ὑποτεινούσης πλευρᾶς τετράγωνον ἴσον ἐστὶ τοῖς ἀπὸ τῶν τὴν ὀρθὴν γωνίαν περιεχουσῶν πλευρῶν τετραγώνοις.
> 'In any right-angled triangle the square on the side subtending the right angle is equal to the squares on the sides containing the right angle.'

The language itself is also very uniform.[28] Acerbi (2021: 1) has described this language in detail, including statistical material and concluding that it is a *Kunstsprache* 'exhibiting a limited lexicon and highly regimented syntactic features, which in some cases may well be termed "extreme"'. The technical nominal lexicon is small and is in a one-to-one correspondence with the geometric objects covered (list in Acerbi 2021: 35–36). For other PoS, there is more variation, especially some unexpected synonyms – διπλάσιος, διπλασίων, διπλοῦς ('double'; 36) – but the number of lemmata and distinct words is very small compared to other Greek texts, as we shall see. Concrete geometric objects are designated by algebraic letter-names such as 'AB', each letter standing for one point. Thus, in Euclid we find a very specialised type of language: the vocabulary is small, synonyms are avoided, unambiguity is sought; but, of course, it is a rather specialised vocabulary with many words for things that do not exist outside geometry. Words for such new geometric objects could be coined easily in the Greek language, which

27 For a full example in translation, see Acerbi (2021: 3–4).
28 So much so that there is an online course for learning Greek just to read Euclid: http://mysite.du.edu/~etuttle/clas.

is very fond of compounds – like Sanskrit but in contrast to Latin and Arabic. A few examples show that (i) some terms could be taken from everyday language more or less as is (e.g. σημεῖον, 'point'; γραμμή, 'line'; ἐπιφάνεια, 'surface'; γωνία, 'corner'; κύκλος, 'circle'; ἴσος, 'equal'; ἄνισος, 'unequal') or in a more technical but still recognisable way (κάθετος, 'let down (of a plumb line) → perpendicular'; ἀμβλύς, 'blunt → obtuse (angle)'; ὀξύς, 'pointy → acute (angle)'; μονάς, 'solitary, by oneself → (mathematical) unit'). Some (ii) are hardly still recognisable, such as ῥόμβος ('rhombus'), normally a sound-producing cult instrument similar to the Australian bull-roarer of rhomboid shape, or ἀντιπάσχω ('to be reciprocally proportional', literally 'to suffer in turn'). Many others (iii) are just compounds of everyday words that are immediately understandable for a Greek-speaker (e.g. εὐθύγραμμος, 'rectilinear'; ἡμικύκλιον, 'semicircle'; ἰσόπλευρον, 'equilateral'; ἀσύμπτωτα, 'which never meet'; ἰσογώνιον, 'equiangular'; διάμετρος, 'diameter'). (iv) Compounds may, of course, also contain parts that may not be familiar to the non-geometrician, such as δωδεκάεδρον ('dodecahedron'), where ἕδρα means 'face of a geometric figure' (usually it means 'seat', and a non-geometer would hardly know what a 'twelve-seater' is).

The syntax is equally monotonous, as the few numbers in table 25 suggest: among these values, conditional clauses (εἰ, ἐάν, ἐπεί) are very common, as is parataxis using καί ('and'), γάρ ('for'), or very frequently ἄρα ('thus'). Infinitives and participles are much rarer than usual in Greek. Of the linguistic phenomena typical for Greek scientific writing (as will be seen below in Aristotle), absolute and participial constructions are rare, but the article is used a lot more than in other Greek. Indeed, the feminine article without any noun except a formula (e.g. ἡ AB) signifies a 'line' (ἡ γραμμή) through A and B, its neuter τὸ A a 'point' (τὸ σημεῖον), and its masculine ὁ ΑΒΓ a 'circle' (ὁ κύκλος). There are also more such short designations: τὸ ἀπὸ AB for the square (τὸ τετράγωνον) 'on' AB, ἡ ὑπὸ ΑΒΓ for the angle (ἡ γωνία) 'under' the three points.[29] But this latter feature is, of course, not essential for geometry; it just shortens the text by saying ἡ AB ('AB') instead of ἡ γραμμή, AB ('a line, called AB')[30] each time.[31] Such letter symbols make up a full 16% of all words in the *Elementa*. Together with the article they make up more than a third of all words in the *Elementa*. Acerbi (2021: 86) points out:

29 A full list of such abbreviated namings of geometric entities in Acerbi (2021: 42–44).
30 See Acerbi (2021: 81–83) on the precise meaning of these letter symbols as names.
31 But brevity is much appreciated by scientists; compare the famous Indian saying that grammarians rejoice about the saving of a syllable as much as about the birth of a son (in *Paribhāṣenduśekhara*, ed. Kielhorn, p. 115).

> The article that precedes the letters has two functions. The first is distinguishing between objects designated by identical strings of letters, because the gender of the article is the same as that of the noun modified by the string of letters: ὁ ΑΒΓ is a circle but τὸ ΑΒΓ is a triangle – for instance inscribed in circle ὁ ΑΒΓ [...]. The second function is to produce a linguistic item suited to be a noun, which must have a declension: the case of the noun can only be deduced from the case of the article.

This latter function is found below to be a crucial feature of Greek scientific language in general (chap. 24 §6). None of the studied translations was able to reproduce this special feature of Greek geometry as none of these languages disposes of an article and three genders.

Table 25: Frequencies in ‰ of some structure words in the texts we consider in comparison to a large general Greek corpus. Striking differences from the Perseus corpus are underlined.

	Euclid, *Elementa*[32]	Aristotle, *Poetica*[33]	Perseus Greek[34]
καί	40.89	53.57 (38.16)	47.79
ἄρα	24.75	0.75 (0.64)	0.57
εἰ (incl. ἐάν)	5.80	3.86 (6.10)	3.80
ἐπεί	7.00	1.04 (1.34)	0.61
γάρ	6.31	18.17 (16.03)	8.71
Article	220.85	78.49 (68.96)	76.36
Relative pronoun	18.32	10.55 (8.93)	9.76
Infinitives[35]	1.59	22.18 (15.35)	23.44
Medio-passive participles	9.46	14.07 (17.15)	20.27
Number of words	152,688	10,233 (1,077,161)	3,791,102

Although the genitive absolute is a very concise means of formulating the conditions under which something is to hold true or happen, it is only rarely used by

32 Data from *TLG* (Heiberg's edition without the material in the appendix). Acerbi (2020: 32) provides further data about PoS in the *Elementa*.
33 The work is somewhat too short to produce reliable figures, so I have added numbers for the entire Aristotelian corpus on CC in parentheses.
34 The freely downloadable Perseus Greek text corpus (as of July 2015) was used.
35 Searched like this: grep -c 'εῖν \\|ᾶν \\|ειν \\|σθαι ' and '[^]μ[εέέ]ν[^][^]*[ς] ' (which also finds a few false positives).

Euclid.[36] Together with conditional ἐπεί clauses, it would seem the natural means for formulating theorems.[37] Figures for Aristotle's *Poetica* are also shown in table 25. Its language is much closer to ordinary Greek in the features considered, although there are exceptions. Most notably, the logical γάρ ('for') and the if-words are much more common in Aristotle (though not in the *Poetica*). As was shown in the previous chapter, Aristotle often used existing words in a narrowed-down, more precisely defined way. Indeed, he often resolves apparent problems by finding that a word means several things (the famous πολλαχῶς λέγεται; see chap. 7 §6). As the preserved Aristotelian works are notes from his lectures, his language is somewhat terse and could today be seen as university-lecture-like, sometimes rather compressed. As observed (chap. 21), new coinings, which would in Greek usually be compounds, are relatively rare in Aristotle. Here is an illustrative compressed sentence from the *Poetica* (1.2–3, 1447a15–18, ed. Tarán & Gutas, p. 165):

> πᾶσαι τυγχάνουσιν οὖσαι μιμήσεις τὸ σύνολον. Διαφέρουσι δὲ ἀλλήλων τρισίν· ἢ γὰρ τῷ γένει ἑτέροις μιμεῖσθαι, ἢ τῷ ἕτερα, ἢ τῷ ἑτέρως καὶ μὴ τὸν αὐτὸν τρόπον.
> 'All of these may be said on the whole to be representations/imitations. But they differ one from the other in three ways: either representing/imitating by [using] generically different [means], or [representing] different [objects], or [representing them] differently and not in the same manner.'[38]

The two works in translation

§5 In order to study the translatability of these two kinds of scientific Greek, a look is taken first at representative sentences in the translations, then at a list of technical terms and how the translators dealt with them, and finally some figures about the translations are considered. In the case of Euclid, most translations rewrite the text more than translating it: they add comments, make little changes to the proofs, even correcting minor mistakes here and there. Some add long commentaries, such as Clavius, Ḥaǧǧāǧ, and Ps-Ṭūsī; on the other hand, the Sicilian

36 e.g. *Elementa* I, prop. 16, ed. Heiberg, vol. 1, p. 42: Παντὸς τριγώνου μιᾶς τῶν πλευρῶν προσεκβληθείσης ἡ ἐκτὸς γωνία ἑκατέρας τῶν ἐντὸς καὶ ἀπεναντίον γωνιῶν μείζων ἐστίν ('For any triangle – one of its sides having been produced – the exterior angle is larger than the interior and opposite angles').

37 Latin's equivalent, the *ablativus absolutus*, is often used thus, for instance in Newton's Latin. Netz (1999: 259) claims that in Greek mathematical writings the *genetivus absolutus* and infinitives are most common in the *protasis*. This is not true for the *Elementa*, where this feature hardly occurs.

38 For the rendering, compare Fuhrmann's translation in his edition.

translation from the Greek is slavishly verbatim. Here is the above example (*Elementa* I, prop. 47, πρότασις) again, with the syntax marked in brackets:

> (Ἐν τοῖς ὀρθογωνίοις τριγώνοις) {τὸ [ἀπὸ τῆς (τὴν ὀρθὴν γωνίαν) ὑποτεινούσης πλευρᾶς] τετράγωνον} ἴσον ἐστὶ {τοῖς ἀπὸ [τῶν (τὴν ὀρθὴν γωνίαν) περιεχουσῶν πλευρῶν] τετραγώνοις}.
> '(In right-angled triangles) {the square [on the side (subtending the right angle)]} is equal {to the squares [on the sides (containing the right angle)]}.'

The statement is strongly syntactically nested, a structure which can be imitated with varying degrees of success in the different languages. The Sicilian translation formulates (*verbum de verbo*, including imitating the article with *quod*):

> (In orthogoniis trigonis) {quod [a (rectum angulum) subtendente latere] tetragonum} equale est {eis que [a (rectum angulum) continentibus lateribus] quadratis}.

Gerard of Cremona translated from Arabic, but the result is much more Latin. Gerard made the best translation from the Arabic according to Busard (edition, p. 25), but was unfortunately little read:

> {Quadratum [ex latere (trianguli rectanguli) (recto) subtenso (angulo)] factum} {duobus quadratis factis [ex duobus lateribus (rectum) continentibus (angulum)]} est equale.

Clavius (1594 edition, p. 83) writes normal, yet perfectly understandable Latin, introducing relative clauses. He adds the underlined words for clarity:

> (In rectangulis triangulis), quadratum, {quod [a latere (rectum angulum) subtendente] <u>describitur</u>}, aequale est {eis, [quae (a lateribus (rectum angulum) continentibus) <u>describuntur</u>], quadratis}.

Heiberg translates similarly into modern academic Latin. Ḥaǧǧāǧ (p. 172) works with participles (underlined), especially often of *kāna* ('to be') and also relative clauses (*italics*). A *verbum de verbo* English translation is given.

> [kullu muṯallaṯin (<u>qāʾimi</u> l-zāwiyati)] fa-ʾanna [l-murabbaʿa <u>l-kāʾina</u> mina l-ḍilʿi (*llaḏī* yūtiru l-zāwiyata l-<u>qāʾimata</u>) musāwin [li-maǧmūʿi l-murabbaʿayni (<u>l-kāʾinayni</u> mina l-ḍilʿayni l-bāqiyayn)].
> '[Every triangle (standing according to the angle)], and behold: [the quadrilateral being of the side (which spans the right angle)] is equal [to the sum of the two quadrilaterals (being of the two sides remaining)].'

The Arabic dual is employed. Samrāṭ (vol. 1, p. ६१) works with compounds and can formulate very concisely indeed in Sanskrit:

(tatra samakoṇatribhujasya) karṇavargo (bhujadvayasya vargayogena) tulyo bhavati.
'(Therefore ⸤of right-angled-triangle⸥) ⸤square of hypotenuse⸥ (⸤of the two-sides⸥ ⸤by square-adding⸥) equal becomes.'

Everything contained in one word is marked here by lower half-brackets. The Chinese translation puts this (in simplified characters, followed by *pīnyīn* transliteration):

凡三边直角形、对直角边上所作直角方形与馀两边上所作两直角方形并、等。
fán sānbiān zhíjiǎo xíng: duì zhíjiǎo biān shàng suǒ zuò zhíjiǎo fāngxíng yǔ yú liǎng biān shàng suǒ zuò liǎng zhíjiǎo fāngxíng bìng, děng.
'For any three-sided shape with a right angle [the following applies]: A square shape made above the side facing the right angle and the two square shapes made above the sides of the other two angles combined [are] equal.'

Apparently, Arabic and Sanskrit use opposing strategies: while Sanskrit uses compounds, Arabic resorts to clauses. Chinese uses neither; it states all that is needed paratactically. The Latin syntax can remain much closer to the Greek than the other languages considered here, but like Arabic it tends to use more relative clauses.

The following table (table 26) lists the translations of some of the geometric vocabulary; relatively straightforward examples are given first, then less easily translatable ones. For Sanskrit, the constituent parts of compounds are marked by dashes. Literal translations are added for interesting cases.

Table 26: Some examples of the translation of technical terminology; loanwords are <u>underlined</u>; non-technical meanings are provided for the non-classical languages. 'Adel.' stands for Adelard of Bath, 'Camp.' for Campanus of Novara, 'Ger.' for Gerard of Cremona, 'Hei.' for Heiberg, 'Robt.' for Robert of Chester, 'Tine.' for Johannes de Tinemue.

Greek	Latin (Anonymus Siculus)	Latin (others if different)	Arabic	Sanskrit	Chinese
γραμμή	*linea*		*ḫaṭṭ*	*rekhā*, *sūtraṁ*	线 *xiàn*
εὐθεῖα (γραμμή)	*recta* (*linea*)		*ḫaṭṭ mustaqīm*	*sarala-rekhā*	直线 *zhíxiàn*
ἡ (εὐθεῖα) AB	(*recta*) *AB*		(*ḫaṭṭ mustaqīm*) *A B*	*a-ba-rekha*	甲乙直线 *jiǎyǐ*[39] *zhíxiàn*
γωνία	*angulus*		*zāwiya*	*koṇaḥ*	角 *jiǎo* ('horn')
εὐθύγραμμος	*rectilineus*		*mustaqīm*	*sarala-rekha-*	直线 *zhíxiàn*

39 Literally 'first-second'.

Table 26: (continued)

Greek	Latin (Anonymus Siculus)	Latin (others if different)	Arabic	Sanskrit	Chinese
κάθετος	*cathetus*	*alhamud* (Camp.), *perpendicularis* (others)	*ʿamūd* (‘pillar’)	*lamba-rūpe*	直角 *zhíjiǎo*
κέντρον	*centrum*		*markaz* (‘centre’)	*kendraṁ*[40]	圜心 *huán xīn* (‘circle heart’)
διάμετρος	*diametros*	*diametrus*, *diameter* (others)	*quṭr* √‘to drop’, noun < *tractus terrae* (Freytag)	*kendro-parigataṁ* (‘gone through’)	圜界线 *huán jiè xiàn* (‘circle boundary line’), 径為圜 *jìng wèi huán* (‘path for circle’)
τρίγωνον	*trilatera figura*	*triangulum* (Camp.)	*muṯallaṯ* (‘triple’)	*tri-bhujaṁ*[41]	三边形 *sānbiān xíng* (‘three edge shape’)
ἰσόπλευρον	*isopleurum*	*aequilaterum* (Robt., Camp.)	*muṯallaṯ mutasāwī l-āḍlaʿ* (‘… same of sides’)	*sama-tri-bāhukaṁ* (‘same …’)	(三边形)三边线等 *(sānbiān xíng) sānbiānxiàn děng* (‘three edge equal’)
ἰσοσκελές	*isoskeles*	*alia figura* (Robt. (!)), *triangulus duorum equalium laterum* (Adel., Ger.)	*muṯallaṯ mutasāwī l-sāqayni* (‘… same of two legs’)	*sama-dvi-bāhukaṁ* (‘same two sides’)	(三边形) 有兩边线等(*sānbiān xíng*) *yǒu liǎngbiānxiàn děng* (‘having two edge equal’)
τραπέζιον	*trapezia*	*elmunharifa* (Robt.), *irregulares* (Adel., Ger.)	*munḥarif* (‘deviant, pervert’)	*viṣama-koṇa-sama-catur-bhujaṁ* (‘un-same angle …’)	无法四边形 *wúfǎ sìbiānxíng* (‘no law four edge shape’)
παράλληλοι	*parallila* (also Camp.)	*linea recta equidistans* (Ger.)	*mutawāzin* (‘balanced’)	*samānāntarāla-rekhā* (‘same intermediate-space line’)	平行 *píngxíng* (‘flat/even go’)

40 The *-d-* is unexpected and reminds one of the Modern Greek pronunciation. Was the translator in contact with Greeks?

41 Literally ‘three-armed, three-sided’, more usually *trikoṇa-* (‘three-angle, three-corner’); Samrat also uses *tribāhukaṁ* (not in Monier-Williams).

Table 26: (continued)

Greek	Latin (Anonymus Siculus)	Latin (others if different)	Arabic	Sanskrit	Chinese
παραλληλό-γραμμον	<u>*parallilogram-mum*</u>	*superficies ex equidistantibus lateribus* (Ger.)	*suṭūḥ al-mutawāzī* ('(of) parallel sur-faces')	*sama-koṇa-ca-tur-bhuja-kṣe-traṁ* ('field/figure')	平行线方形 *píngxíng xiàn fāngxíng* ('paral-lel line square shape')
λόγος	*proportio*	*ratio* (Hei.)	*nisba* ('kinship')	*niṣpattiḥ*, f. ('going forth or out')	比例 *bǐ lì* ('compare prece-dent')
ὑποτείνουσα	*subtendens*	*subtendo* (verbal; Hei.)	*wattara* ('stretch')	*karṇaḥ* ('(furn-ished with) ear (s)' (!))	对 *duì* ('facing/opposite')
ἀντιπάσχω	*contraria passe* [*sic*]	<u>*mutekefie*</u> (Adel.), *mutuus seu* <u>*mutekefie*</u> (Tine.), *mutuorum laterum* (Robt., Camp.), *in contraria ratione* (Hei.)	*mutakāfiʾa* ('equivalent')	*ekarūpa-niṣpat-tistve karmin* ('making by uniform propor-tion')	互相視之 *hùxiāng shì zhī* ('reciprocally regard it')
πρῶτος ἀριθμός	*primus numerus*		*ʿadad ʾawwalī* ('first number')	*prathamāṅka* ('first number')	not in books I–VI
ἄλογος	<u>*aloge*</u>	*irrationalis* (Robt.)	*ġayr nisbī* ('non relative'), *ġayr manṭiq* ('non logic')[42]	*karaṇī*[43]	not in books I–VI
πρίσμα	<u>*prisma*</u> (also Hei.)	*corpus serratile* (Robt., Camp.)	*manšūr* ('spread out')	*chedita-ghana-ksetraṁ* ('divided solid')	not in books I–VI
δωδεκάεδρον	<u>*dodecaedron*</u>	*corpus duodecim basium pentago-narum equilater-arum* (Robt.), <u>*dodecaedrum*</u> (Hei.)	*iṯnā ʿašara suṭūḥ* ('(of) 12 sides')	*sama-bhuja-dva-daśa-phalaka-kśetraḥ* ('... 12-slab ...')	not in books I–VI

42 The root *nṭq* means *articulatam et significantem protulit vocem* (Freytag, s.v.), the noun *prolata oratio; logica*.
43 This word 'originally meant a cord of reeds used by the sacrificial priest to measure the side of the square altar' (*Rekhaganita*, vol. 2, appendix 2, p. 12). It is totally unrelated to its opposite, *mū-ladarāśiḥ* (ῥητός, *rationalis*).

Clearly, many of these terms had to be newly invented by the translators. An example for which all other languages needed lengthy descriptions is παραλληλόγραμμον; others, such as πρῶτος ἀριθμός, were easy to imitate (only English uses Latin 'prime', not the expected 'first number'). The Sicilian translator often just transliterates difficult Greek terms (occasionally including verbs such as παραβάλλειν; I.44),[44] Robert does the same for Arabic (*elmunharifa* for 'trapezium'), as does Adelard with *mutekefie* ('being reciprocally proportional') or *alkaida* for *basis*. The later Latin translations tend to use much less direct loans. Arabic, Sanskrit, and Chinese do not usually take direct loans at all,[45] Samrāṭ's *kendraṁ* (κέντρον) is an exception. The more complex notions are rendered by compounds in Sanskrit and *constructus* clauses in Arabic,[46] which clearly feels much less at home with these formulations than Sanskrit, with its compounds, does. For instance, Samrāṭ writes the descriptive and very clear, although rather long compound *viṣama-koṇa-sama-catur-bujaṃ* ('not-same-angle-same-four-sider') for 'trapezium'. In Chinese such concepts are formed by combinations of characters, in this case *wúfǎ sìbiānxíng* ('no-law-four-edge-form'), which, however, is less precise. Now, some statistical data about the translations.

Table 27: Statistical data for the Euclid translations (book I only). Characters are counted without spaces. The zipped bytes measurement (of a .txt file containing the text) is used as an estimate of the information content.

	Greek	Latin, Anonymus Siculus	Latin, Gerard of Cremona	Latin, Clavius	Arabic, Ṭūsī	Sanskrit	Chinese
Words	11,340	9,402	12,600	12,080	14,436	9,663	?[47]
Characters (excluding spaces)	47,150	46,510	67,550	54,220	55,504	82,160	5,925
Zipped bytes	17,291	13,133	19,343	18,131	25,418	26,067	6,363
Distinct words[48]	860/619	907/690	1255/989	1344/1001	1738/1716	3342	321
Lemmata[49]	242	240	403	416	unknown	unknown	321

44 Such cases are listed by Busard in his edition (pp. 14–15).
45 Compare the similar behaviour of Arabic and Chinese in the modern examples in the next chapter.
46 On this construction, see Badawi, Carter & Gully (2004: 130–143).
47 Which combinations of characters should count as one semantic unit ('word') is often unclear in Chinese; preferably, one just counts characters.
48 The first number includes names for geometric objects, such as *AB*, as 'words'.
49 Not counting proper names. The numbers were automatically calculated in Corpus Corporum using word-lists mostly from Perseus. In ambiguous cases, the first lemma was chosen and some

It is to be remembered that Gerard translated from Arabic and that the Sicilian translation is a *verbum de verbo* translation of the Greek: it reaches amazing *brevitas*. Chinese – both the language and its script – functions completely differently. This makes comparison difficult, but the Chinese translation seems to be very short as well, although the number of unique characters is higher than that of the lemmata in the Greek or in the Anonymus Siculus. Further interpretation is provided in the next section and contrasted with Aristotle.

Aristotle

§6 For Aristotle's *Poetica*, the statistical data is provided first (in order to keep the two tables close together), then we consider a representative sentence and the translations of some technical terms.[50]

Table 28: Statistical data for the *Poetica* translations (for details, see table 27).

	Greek	Latin (Moerbeke)	Arabic (Abū Bišr)	Sanskrit (Nath)[51]
Words	10,262	9,314	11,127	8,089
Characters (excluding spaces)	50,108	54,915	59,903[52]	73,550
Zipped bytes	33,509	23,618	31,917	43,007
Distinct words	2,662	2,560	3,339	4,933
Lemmata[53]	1,368	1,598	unknown	unknown

Here, the Sanskrit translator has to circumscribe many facts of Greek cultural life, and the wording becomes longer, in contrast to the Euclid translation above. Again, the information content speaks for Latin *brevitas;* the near-equal number of distinct words in Greek and Latin is, again, a consequence of the translation technique. The above example sentence (*Poetica* I.1, 1447a16–18) is translated by Moerbeke (p. 3) as:

uncertainty (up to some 5 %) must be expected. The lemmatising feature only works for Latin and Greek, so we have no numbers for the other languages.

50 I could not find a digitally available Chinese translation of this text.

51 The numbers are based on automated OCR, so an error margin of up to some 5 % must be allowed for. The character count is based on the transliterated forms. As words are often not separated in the Devanagari script, the numbers for words and distinct words will not be very accurate.

52 Counting only the written consonant characters, thus without vowels.

53 Same way of counting as in the previous table.

differunt autem ab invicem tribus: (i) aut enim per genere alteris imitari, (ii) aut per altera, (iii) aut per aliter et non eodem modo.

The Arabic translator Abū Bišr (p. 220) expands this rather condensed statement considerably:

w-ʾaṣnāfu-hā ṯalāṯatun: (i) wa-ḏālika ʾima ʾan yakūna yušbihu bi-ʾašyāʾi ʾaḫari wa-l-ḥikayatu bi-hā, (ii) wa-ʾima ʾan takūna ʿalā ʿaksi hāḏā: wa-huwa ʾan takūna ʾašyāʾu ʾaḫaru tušbihu wa-taḥākī, (iii) wa-ʾima ʾan tağrā ʿalā ʾahwālin muḫatalifatin lā ʿalā ğihatin wāhidatin bi-ʿayni-hā.
'And [there are] three classes of it: (i) that is to say either that they are imitating in other things and the imitation [is] in them, (ii) or that they are contrary [to] this, and they are in other things imitating the imitation, (iii) or that it works with different situations, who are not one-and-the-same in respect.'[54]

Sanskrit is again very concise for such sūtra-like statements, basically reducing the three possibilities to one compound (p. 3):[55]

tathāpi tāni anukaraṇasya mādhyama-viṣayaṁ-rīti-dr̥śā tridhā 'nyonyam vibhajyante.
'Even so, these [kinds] of imitation ⌞by middle-topic-diction-appearance⌟ in three parts from one another are distinguished.'

The translation of scientific descriptions of matters rooted in a particular culture cannot work without a rather deep knowledge of the culture in question – in contrast to geometry, which travels much more seamlessly. The uncommon vocabulary in the *Poetica* consists mostly of names of genres and poets. Abū Bišr, an Aristotelian logician, is not interested in the performance of these Greek forms of art at all. Nath provides a list of his transliterations of those terms unfamiliar within Sanskrit, but taken to be familiar to his readers in their international (i.e. English) form, for example *dithurambaḥ* or *platān*, for 'dithyramb' and 'Plato' respectively, which are well formed and can be easily declined in Sanskrit.[56] Rigolino (2013: 146) concludes about the Arabs:

Their awareness of Greek literature was scarce, but nevertheless they were not prevented from reading and studying Aristotle's *Poetics*, a treatise dealing with Greek drama. Rather, the distance that separated Greek and Arabic literatures prompted translators and later

54 Tkatsch translates (p. 221): *Et species eorum (sunt) tres. Etenim aut adsimulant per res alias et (fit) imitatio per eas aut sunt contraria, quod quidem res aliae adsimulant et imitantur aut fiunt modis diversis, non ratione una ipsa.*
55 This is typical for Sanskrit's *sūtra* style: texts are very condensed and easy to learn by heart. But they need to be elucidated by commentaries or by a teacher.
56 Unlike what the Sanskrit Wikipedia proposes: *plāton*.

scholars such as al-Fārābī, Ibn Sīnā and Ibn Rušd to put forward their interpretations of the Aristotelian text.

Again, translations of key vocabulary are compared in table 29.

Table 29: Some examples of the translation of technical terminology; loanwords are underlined. The numbers indicate the chapter in the *Poetica* where a word is found.

Greek	**Latin**	**Arabic**	**Sanskrit**
(1) τραγῳδία	*tragodia*	*madīh*	*tragādī*
κωμῳδία	*komodia*	*hiǧāʾ*	*kāmādī*
ἐποποιία	*epopoiia*	*našīd*	*mahā-kāvya*
(3) δρᾶμα	*drama (idest actitamen)*	*drāmātā* (pl.)	*kārya/drāmā*
δρᾶν	*actitare*	*ʿamila*	*kr̥*
(4) ἑξάμετρον	*exametrum*	*al-ʾawzān al-sudāsiyya* (‘six-fold weights/metres’)	*ṣaṭpadī-br̥tta* (*Hexameter*)
ἰάμβος	*iambus*	*yāmbū*	*yāmbū*
(6) *μίμησις*	*imitatio*	*muḥākāt*	*anukr̥tiḥ/anukaraṇaṁ*
μῦθος	*fabula*	*ḫurāfa*	*katha-vastu* (‘subject matter’)
ἦθος	*mores*	*ʿāda*	*caritraṁ*
λέξις	*locutio*	*maqūl*	*śabdayojanā* [*sic*]
διάνοια	*ratiocinatio*	*iʿtiqād*	*cintā*
ὄψις	*visus*	*naẓra*	*prekṣā*
μελοποιία	*melodie* factio	*naġmat al-ṣawt*	*saṅgītaṁ*
(9) ποιεῖν	*poetizare*	*ʿamila* (compare δρᾶν)	*sraṣṭr̥* (‘[be] creator’)
ποιητής	*poeta*	*šāʿir* (the root means ‘know intuitively’)	*kavi* (‘seer, poet’)
πρᾶξις	*actio*	*ʾirādiyya* (‘intention’)	*ghaṭanā* (‘acting’)
ἐπεισοδιώδης	*episodiodea (idest superadventitia)*	*iqtiṣāṣ*[57]	*prasaṅga* (‘result, consequence’)
(11) ἀναγνώρισις	*anagnorisis*	*istidlāl* (‘argumentation’)	*āviṣkaraṇa (anagnori-sis)* (‘making manifest’)

57 A technical term in Arabic poetry meaning *[q]uod introductio non cohaeret cum ipso carmine scopo* (‘that the occurrence of something [in a poem] does not belong in the context of the poem itself’) or similar (Freytag, s.v.); the main meaning of the root *qṣ* is ‘cut, perforate’.

In this sample, there are a lot more loans in Sanskrit in particular, but there are also some in the Arabic translation. Many of these terms are still used in their Greek form in modern scholarship.

Conclusions from the two texts

§7 Despite the fact that none of the translations was made by the same translator, there are some definite patterns in the statistical figures. In comparison to Euclid's book I (which is of approximately the same size), Aristotle in his *Poetica* uses over five times as many distinct words and lemmata, which says a lot about Euclid's special type of Greek. Latin is the only target language in which translations tend to be shorter than the original.[58] On the whole, the scientific Latin translators tend to translate their Greek originals very closely, sometimes *verbum de verbo*, which generates 'Greek in Latin letters'.[59] Moerbeke uses a Greek term plus *idest* and a tentative Latin equivalent thirty-one times (including cases of quotations that are not translated). This minimises the danger that the translator perpetuates his own misunderstandings, but on the other hand the result is quite unintelligible for someone who has not learned to understand this Greek syntax in Latin and thus to adopt a Greek *Denkstil*. The main problems in translating Greek science into Latin are discussed below (chap. 24 §§5–8): lack of article, compounding, and suffixation.

In the other three languages, such a procedure was clearly impossible, as the languages are unrelated (or at least do not share the *Begriffsgemeinschaft,* as in the case of Sanskrit) and work rather differently syntactically. In Arabic, translators had to reformulate many things; compounds in particular – as seen in the list for Euclid – were often turned into *constructus* clauses. Besides, it was noted that the Arabic translators had a tendency to be rather prolix, for instance to say things twice with slight variation. In Sanskrit things are again very different: this language is so fond of compounding that the number of words tends to become less in translating (though not the number of characters). Samrāṭ even makes compounds of geometric objects and speaks of, for instance, the 'A–B-line'. Nath makes compounds of lists.[60] Sanskrit is famous for its special scientific language,

58 The same is apparently true for Chinese, whose writing system gives it a natural tendency to brevity.

59 More on this technique in chap. 10 §5 above and Roelli (2014a). In early Church texts, this was very different; although there was a wide spectrum from verbatim to very free translations, the *verbum de verbo* type is hardly ever encountered (Gleede 2016: 356).

60 Such as *mahākāvyā-tragādī-kāmādī-stutikāvyāni* for Ἐποποιία δὴ καὶ ἡ τῆς τραγῳδίας ποίησις, ἔτι δὲ κωμῳδία καὶ ἡ διθυραμβοποιητική (1.2, p. 238).

which goes so far as to give cases specialised scientific functions in the sentence.[61] For instance, causes are indicated by a bare ablative. A normal speaker or reader of the language who is unaware of these special rules will be unable to understand anything in such a text. A similar heavily nominal style can be observed in German, but it resorts more to compounding and, unlike Sanskrit, does not go so far as re-engineering its syntax.[62]

It can be concluded that Euclid is much easier to translate than Aristotle due to several factors. Not only is Euclid's content more easily accessible to non-Greeks than the Greek art forms studied by Aristotle's *Poetica*; it would also seem that a highly formalised language using a small and well-delineated vocabulary and simple syntax also helps a lot in this respect. However, Euclid's highly formalised language can even be formalised and compressed much further, as is indeed done in modern mathematics. Thus, these two statements amount to the same thing:

> Ἐὰν ὦσιν ὁσοιδηποτοῦν ἀριθμοὶ ἑξῆς ἀνάλογον, ἀφαιρεθῶσι δὲ ἀπό τε τοῦ δευτέρου καὶ τοῦ ἐσχάτου ἴσοι τῷ πρώτῳ, ἔσται ὡς ἡ τοῦ δευτέρου ὑπεροχὴ πρὸς τὸν πρῶτον, οὕτως ἡ τοῦ ἐσχάτου ὑπεροχὴ πρὸς τοὺς πρὸ ἑαυτοῦ πάντας. (*Elementa* IX, prop. 35, ed. Heiberg, vol. 2, pp. 404–406)

$$\sum_{i=0}^{n-1} ar^i = a\frac{r^n - 1}{r - 1}$$

On the other hand, in the human sciences, texts are still written in a much less formalised language today, although it is definitely also a highly specialised kind of language with many foreign words (especially Greek and Latin ones) and often still a complicated and non-repetitive syntax which is used to mimic in language complex structures from the field studied. A German example:

> Im Fortgang nahmen dann jedoch Einstellungen überhand, welche die 'fortwährende Normenentfaltung' nicht mehr erkennen, jedenfalls nicht mehr anerkennen wollten, und damit – wohl ohne daß man es wollte, und ohne daß man es merkte – diese zählebige Tradition lebhafter Fortentwicklung zum Verklingen brachten.[63]
> 'In the course of time, however, attitudes prevailed which no longer recognised, or at least no longer wanted to acknowledge, the "progressive unfolding of norms" and thus – prob-

61 More on this *Nominalstil* in Jacobi (1970); see also Staal (1995).
62 Otto Jespersen already noted this similarity in 1924 (quoted in Gordin 2015b: 37).
63 From Stotz (1996–2004: I, §9.11 = vol. 1, p. 35).

ably without wanting to and without even noticing it – it made this persistent tradition of lively further development fade.'

In translating such texts, one faces two problems, one concerning vocabulary and one of syntax and nuances. *Normenentfaltung* may be renderable by 'unfolding of norms', but other nuances can in no way be preserved in the English: consider *zählebig* turning into a mere 'persistent' without the connotation of 'life', or the closeness of *erkennen* and *anerkennen*. The same is true for the musical connotations of *Verklingen*. The first problem can thus be solved relatively easily by taking over the foreign words missing in the target language and hoping that readers will understand them, or alternatively by forming calques (as I did in the example). The next chapter will give further examples of each approach. The second problem is much more tricky, as has been seen in the examples from Aristotle's *Poetica* in this chapter. What we see here may be a difference between natural and human sciences: that the former are much more easily formalised.

On the whole, it would seem that different languages had to master different problems in order to express Greek science. Science can be seen as a web of strictly defined scientific entities. The entities need names when translating into a language not yet familiar with the science in question, but the web must also be recreated. The former task is relatively straightforward and can be accomplished by loaning or calquing (as the tables above have shown). The latter option is, in general, to be preferred, as loaned words tend to remain foreign material in the target language that is not well integrated into its semantic web. Think of the famous Russian бутерброд, which does not have to contain butter at all.[64] Indeed, in our examples, later translations have tended to use the calquing more profusely than the former. The web of these new concepts takes time to become established in the target language. Often, this web's internal organisation also has to be changed; for instance, Latin could not use the article to denote lines, points, or circles the way Euclid did in Greek. The next chapter considers the debt of modern vernacular scientific terminology to scientific Greek and Latin.

64 The word's meaning moved to 'sandwich' as users did not understand the part mentioning 'butter'. The Russian Wikipedia defines: ломтик хлеба или булки, на который положены дополнительные пищевые продукты ('a slice of bread or bread roll onto which further alimentary products are put'; https://ru.wikipedia.org/wiki/бутерброд, November 2020).

23 The reuse of Latin in the modern languages of science

§1 It has been claimed that modern science contains more words derived from Greek than Ancient Greek had as a whole.[1] Now, this is hardly a scientific statement:[2] Ancient Greek could easily coin new words and no one knows how many were ever used. Indeed, the question of how many words a language possesses is seen as meaningless today. Nonetheless, the number of scientific English words today made up from Greek constituents is very large indeed. This chapter continues the previous chapter's approach to comparing what languages do with the Greek and Latin scientific word material, but this time the focus is on contemporary languages of science, which are all clearly dependent in their content on European science and thus Graeco-Latin science.

§2 A sample of technical terms in two very different sciences[3] in eight languages is considered here in order to see how languages solve the task of taking over modern Western European scientific content: on the one hand chemistry, in its current form a young science (Lavoisier discovered the periodic table in 1789) with many new concepts that came into being only after the hegemony of Latin was broken, on the other hand linguistics, which is based on ancient grammar theory and vocabulary, but also developed in strikingly novel ways in the eighteenth and nineteenth centuries. I picked a dozen terms from each of the sciences in question, quite at random but from different topics and taking care to cover different PoS, and then I checked how the languages in question express them. Even at a glance, it will become apparent that most of them are based on Greek or Latin: both these languages are still in high favour today among people inventing new scientific concepts (see chap. 21 above). The languages chosen were French, English, German, Icelandic, Russian, Modern Greek, Arabic, and Chinese.[4] A first cri-

1 A version of this chapter was presented at the congress 'Deutsch als Wissenschaftssprache um 1800', Berlin, June 2016, organised by Claude Haas and Daniel Weidner.
2 The claim comes from Hitchings (2008: 182), quoted in Gordin (2015b: 299).
3 As Fleck already pointed out: 'Der Zusammenhang z. B. von Linguistik und Chemie ist tatsächlich geringfügig' ('The connection of, for instance, linguistics and chemistry is indeed slight'; 2011: 368).
4 For Icelandic, I used *Icelandic Online Dictionary and Readings*, *Ritmálssafn Orðabókar Háskólans*, Böðvarsson, and de Vries; for Russian Derksen and Vasmer; for Modern Greek Μπαμπινιώτης; for Arabic Lane, Freytag, and *Aratools*; for Chinese *Chinese MDBG Online Dictionary*. For all languages, Wiktionary was also consulted.

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terion for inclusion was that a language should be internationally relevant in the sciences today, adding Icelandic, which is known for hardly ever admitting loanwords, as well as Modern Greek and Arabic as the direct descendants of once very important languages of science. French can stand for the Romance languages in general, which tend to be very similar in their scientific vocabulary, and Russian for the Slavonic ones. English, German, and Icelandic will show the diversity among the Germanic languages, which range from largely borrowing from Latin to nearly exclusively making their own calques. Chinese is included as an outlier, a culture that had its own kind of scholarship that hardly ever borrows directly and much of which depends on its complex and archaic writing system. Due to this, the Chinese characters are included as they have their own etymologies, the pronunciation often being polysemous.

Tables 30 and 31 provide the structure of the sampled words by adding morpheme-by-morpheme translations. The lists also contain a – mostly approximate – date for each concept's first use. It would be very interesting to have access to such dates for all the languages in question, but most languages are not as well documented as English and have no equivalent of the *OED*. The character '°' indicates the language in which the concept was probably first used; *italicised* terms are based on Greek or Latin, other loanwords are formatted in **bold**, and calques are <u>underlined</u> – in other words, terms not specially formatted are 'native'. The last row attempts to summarise these pieces of information by giving figures for how often a concept originated in the column's language, how often it stemmed from the classical languages, how often there was a loanword, and how often a calque. This system is too primitive to account for all cases. For instance, how should a word be counted that is coined in German but from Greek constituents (such as *Morphem*)? The numbers should thus be taken only as a quick overview of the favoured types used in the different languages. In some cases, especially in linguistics, there is no available standard term in some of the languages; these cases are marked with '?'. Such cases were rather to be expected – as science is not as easily and automatically translatable, as has sometimes been claimed (chap. 16 §1) – but they are quite rare.

§3 A few more words on Chinese and its writing system may be helpful for readers not familiar with language and script. Basically, one character represents one concept, although today two near-synonyms have often coalesced into one 'word' as there are so many homophones (e.g. 啤酒 *píjiǔ* literally 'beer-liquor', but in fact the normal term for 'beer'). The characters were already standardised in Xǔ Shèn's (ca. AD 58–ca. 148) lexicon *Shuō wén jiě zì*, which contains some 9,500 characters and already uses a classification of simple characters, compound characters, and radicals (used to sort the characters). The basis of the modern standard lexicon is the *Kāngxī zìdiǎn* (from 1710) with some 47,000 characters ordered by 214 radicals. Character compounds can contain semantic and phonetic components (phonetic for Mandarin, that is). For example, the character 鈈 *bù* ('plutonium') is formed from 金 *jīn* ('metal') and 不 *bù* ('nothing'), which has the same pronunciation but whose meaning has nothing to do with 'plutonium'. In fact, this is a general characteristic of the Chinese script. For example, the character 语 *yǔ* ('language') consists of 讠 ('speech' radical) + 口 *kǒu* ('mouth') + 五 *wǔ* ('five'); this last component is purely phonetic – it sounds similar to *yǔ*.[5] Equipped with this writing system that contains much of Chinese culture and ideology, Chinese goes very much its own way when dealing with new concepts. It only reluctantly and still very rarely begins to adopt occasional loanwords in the twentieth century,[6] for instance 代拿买特 *dàinámǎitè* ('dynamite').[7] Within this writing system, such an approach is problematic, as each character not only has a pronunciation but also a meaning, in this case 'period', 'catch', 'buy', 'unique' – which has absolutely nothing to do with 'dynamite'. There is a state institution that takes care of standardising new scientific coinings in the People's Republic.[8] With great effort, this system inherent in Chinese writing was put to use in expanding scientific terminology in Chinese and was successful in adopting the Western scientific *Begriffsgemeinschaft*. In Chinese, new concepts are very often expressed by character compounds or by adding strokes to existing characters.

§4 The sample words follow in tables 30 and 31.

5 More on Chinese writing and its history in Bottéro (2001).
6 One might think that their very different phonetics prevent the Chinese from loaning, but as Japanese (with a similar phonetic problem) shows, this is not the case: *dainamaito* ('dynamite'), *gurukōsu* ('glucose'), *metafijikkusu* ('metaphysics'), and many more examples, all written in syllabic katakana script, are normal Japanese today.
7 See Yeun-wen Pao (1983) and the wiki list https://en.wikipedia.org/wiki/List_of_loan words_in_Chinese. Today, there are other native terms for 'dynamite' in Chinese, such as 甘油炸药 *gānyóu zhàyào*, literally 'glycerine explosive'.
8 http://www.most.gov.cn/eng/ .

Tables 30 and 31: Some concepts from chemistry and linguistics, respectively, in eight languages. For the formatting, see §2 above.

Latin	**Age**[9]	**French**	**English**	**German**	**Icelandic**[10]	**Russian**	**Greek (modern)**	**Arabic**	**Chinese**[11]
°*inertia*	ant.	*inertie*	*inertia*	Träg-heit ('inert-ness')	treg-ða ('inert-ness')	инерт-ность ('inert-ness')	νωθρότητα ('in-ertia/sloth')	quṣūr ḏātī ('constrain-self')	慣性 guàn xìng ('usual nature/ character')
°*vis*	ant.	force	force	Kraft ('force/ strength')	kraftur ('force/ strength')	сила ('force/ strength')	δύναμι ('force/ strength')	quwwa ('force/ strength')	力 lì ('strength')
saccharum[12] -a- < Pers.	med.	**sucre** -*u*- < Ar.	**sugar** -*u*- < Ar.	**Zucker** -*u*- < Ar.	**sykur** -*u*- < Ar.	**сахар** -*a*- < Pers.	**ζάχαρι** -*a*- < Pers.	**sukkar** < Sanskrit	糖 táng < 米 ('rice') + 唐 (phonetic part)
destillare	med.	*distiller*	*to distil*	*destillieren*	ad eima ('to steam' < eimur, 'steam')	дистиллиро-вать	°ἀπο-στάζω[13] ('off-drop')	√qṭr ('drip'; noun: taqṭīr)	餾 liú ('steam'), 蒸餾 zhēng liú ('evaporate steam')
°*magnetismus*, *vis magnetica*[14]	16th century	*magnétisme*	*magnetism*	*Magnetismus*	segul-magn ('magnet[15]-amount')	магнетизм	μαγνητισμός	*miġnāṭisiyya*	磁 cí < 石 ('stone') + 兹 (phonetic part)
°*gravitatio*, *gravitas*	1633[16]	*gravitation*	*gravitation*	*Gravitation*, Schwerkraft ('heavy-force')	Þyngdar-afl ('weight-force')	гравитация	βαρύτητα ('weight')	ǧāḏibiyya < √ǧḏb ('attract')	引力 yǐn lì ('draw' 'force')

9 'Ant.' stands for 'Antiquity', 'med.' for 'mediaeval'.
10 My thanks to Linda Gíslason for checking the Icelandic.
11 My thanks to Guanzhong Quan for his help with the Chinese terms.
12 Ultimately from Sanskrit *śarkarā* ('sugar, gravel, grit'), originally just denoting something granular. The vowel shows whether a language borrowed through Arabic or Persian.
13 The concept is first encountered in late antique alchemist texts.
14 In Antiquity μάγνης and *magnes* were only used to denote the loadstone; no word for the force was in use.
15 Literally 'sail-stone', i.e. a stone that follows iron like a sail follows the wind. The native term in English for magnet is 'loadstone'.
16 Earliest passage in *OED* for English: 1646. Sennert, *Epitome naturalis scientiae* II.3 (printed 1633), is the first author in Corpus Corporum who uses it (adding *minus latine*). *Gravitas* ('heaviness') already exists in Antiquity.

Table 30 and 31: (continued)

Latin	Age[9]	French	English	German	Icelandic[10]	Russian	Greek (modern)	Arabic	Chinese[11]
°*gas(ium)*[17]	1652	***gaz***	**gas**	**Gas**	loft-tegund ('air-kind')	**газ**	ἀέριον ('airy')	**ġāz**	气 体 qì[18] tǐ ('air/breath' 'body')
molecula	1674	°*molecule*	*molecule*	*Molekül*	sam-eind ('single-particle')	*молекула*	μόριον ('particle')	ǧazīʾ < √ǧzʾ ('divide')	分子 fēn zǐ ('divide small thing/child')
oxy-genium ('sour-becoming')	1777	°*oxygène*	*oxygen*	Sauer-stoff ('sour-stuff')	súr-efni ('sour-material')	кисло-род ('sour-origin')	*ὀξυ-γόνον* ('sour-making')	ʾ**uksiǧīn** < US English	养 yǎng ('nourish') < 气 ('air') + 羊 (phonetic part)
acidum aceticum	1787	°*acide acétique*	*acetic acid*	Essig-säure ('vinegar-acid')	edik-sýra ('vinegar-acid')	уксусная кислота ('vinegary acid')	ὀξικὸν ὀξύ ('vinegary acid')	ḥamd al-ḫalīk ('acid-vinegary')	乙酸 yǐsuān ('second/ethyl-acid')
niccolum	1822	**nickel**	**nickel**	°Nickel	**nikkel**	**никель**	**νικέλιο**	**nīkal**	镍 **niè**[19] < 金 jīn ('gold/metal') + 臬 (phonetic part)
glucosum	1838	°*glucose*	*glucose*	*Glukose*, Traubenzucker ('grape sugar')	*glúkósi*	*глюкоза*	*γλυκόζη*	*ǧlūkūz*	葡萄糖pútáo táng ('grape sugar')
°: 5 0 *10* **2** 0[20]		°: 4 1 *8* **3** 0	°: 0 1 *8* **3** 0	°: 1 4 *5* **3** 0	°: 0 5 *1* **2** 4	°: 0 3 *6* **3** 0	°: 1 3 *3* **2** 4	°: 0 4 *2* **4** 2	°: 0 0 *0* **1** 11

17 A word invented *ex nihilo* (echoing 'chaos') by van Helmont, *Ortus medicinae*, p. 59. http://mdz-nbn-resolving.de/urn:nbn:de:bvb:12-bsb10055180-6.
18 The same character denotes the Chinese metaphysical concept of qi.
19 The same pronunciation, *niè*, also means 'demon; bastard', but is written differently (孽). Our word 'nickel' comes from Swedish *nickel* ('vermummte Schreckgestalt', 'masked figure of terror'; Kluge, s.v. 'Nickel').
20 The first figure (after '°:') is the number of terms that were used first in the language in question. The four figures on the second line are the number of, respectively, calques, terms based on Greek or Latin, other loanwords, and 'native' terms.

Table 30 and 31: (continued)

Latin	Age	French	English	German	Icelandic	Russian	Greek (modern)	Arabic	Chinese
ad-jectivum	ant.	*adjective*	*adjective*	*Adjektiv*, Eigen-schafts-wort ('property-word')	lýsingar-orð ('description-word')	прилагательное ('attached (word)')	°*ἐπί-γθετον* ('placed-onto')	ṣifah < √wṣf ('describe')	形容词 xíngróng cí ('describe word')
prae-dicatum	ant.	*prédicat*	*predicate*	*Prädikat*, Satz-aussage ('sen-tence-statement')	um-sögn ('about-say')	*предикат*, ска-зуемое ('dis-cussed')[21]	°*κατ-ηγορούμε-νον* ('predi-cated')	ḫabar ('report')	谓语 wèi yǔ ('call expression/lan-guage')
syllaba	ant.	**syllabe**	**syllable**	**Silbe**	at-kvæði ('onto' (að)-'poem' (kvæða))	слог ('word/ syllable/ dog-ma')[22]	°*συλ-λαβή* ('tak-ing together')	maqṭaʿ lafẓī ('excerpt word')	音节 yīn jié ('sound segment/joint')
singularis (*nu-merus*)	ant.	*singulier*	*singular*	*Singular*, Ein-zahl ('one-number')	ein-tala ('one-number')	единственное число ('of-one number')	°*ἑνικός* ('of one')	mufrad ('single')	单数 dān shù ('single' 'number')
imperativus (*modus*)	ant.	*impératif*	*imperative* (*mood*)	*Imperativ*	boð-háttur ('pre-cept/invitation-mode')	*императив*	°*ἐπιτακτικός* ('of order')	fiʿl al-ʾamr ('verb-order')	命令式 mìng lìng shì ('order mode')
°*trans-itivum*	13th centu-ry?[23]	*transitif*	*transitive*	*transitiv*	áhrifs-sögn ('in-fluence-verb')	пере-ходный ('through-going')	μετα-βατικός ('through-going')	fiʿl mutaʿaddin ('verb' 'attack-er')	及物 jí wù ('reach thing/object')

21 A present passive participle from an old verb *сказовать; compare Russian сказывать ('to tell a tale').
22 A root noun originally from *so ('with, from') + √leg (лежать) ('lie/be located').
23 Used in this way at least since Peter the Lombard. The preverbs trans- μετα-, пере- nicely correspond to each other here.

Table 30 and 31: (continued)

Latin	Age	French	English	German	Icelandic	Russian	Greek (modern)	Arabic	Chinese
°*vocalis radicalis*[24]	before 1754[25]	*voyelle du radical*	*stem vowel*	Stammvokal ('stem-vowel')	stofn-sér-hljóð ('stem-self-sounding')	гласный основы ('vowel of base')	θεματικόν φωνήεν ('of stem vowel')	(?) aṣl kalima ('root word'; corresponds only roughly)	元音詞幹 yuányīn cígàn ('vowel word stem'; corresponds only roughly)
°*suffixum*	1778, *OED*	*suffixe*	*suffix*	*Suffix*	við-skeyti ('with-combine')	*суффикс*	ἐπί-θημα ('onto-put')	lāḥiqa ('appendix')	后缀 hòu zhuì ('behind' 'combination')
apo-phoniam + verb	1819	subir **ablaut**, *alternance vocalique*	to undergo **ablaut**, *apophony*	°ab-lauten[26]	(?) hljóð-skipti[27] ('sound-shift') + verb	**аблаут**, *апофония* + verb	μετά-πτωσι, *ἀποφωνία* + verb	(?) tanāwaba ḥarakatan, ḥawwala l-ḥarakata[28] ('alter/transfer vowel')	元音变换 yuányīn biànhuàn ('vowel transform'; corresponds only roughly)
lex phonetica[29]	1826[30]	loi phonétique	sound law	°Laut-gesetz ('sound-law')	hljóð-lög ('sound-law')	фонетический закон ('phonetic law')	φωνητικός νόμος ('of-sound law')	(?) taġayyur lafẓī ('change-word')	音规律 yīn guīlǜ ('sound law')

24 *Vocalis* already in Quintilian, *Institutio oratoria* I.7.26, ed. Rahn, vol. 1, p. 112. The entire syntagm in e.g. Kosengarten, *Grammatica arabica*, p. 263.
25 At least since Alvarez (1754).
26 First used as noun and verb by Jacob Grimm (1819: 543).
27 Apparently used like this (Böðvarsson mentions as example the ablaut *bíta–beit–bitum*), although the word would correspond to our 'sound shift'.
28 From https://www.almaany.com/ar/dict/ar-fr/ablation, but an Internet search shows that this term is not in use. For the second option, see https://de.pons.com.
29 Cf. *Lexicon latinum hodiernum:* http://www.lateinlexikon.com.
30 In Bopp (1826), but the word may well be older.

Table 30 and 31: (continued)

Latin	Age	French	English	German	Icelandic	Russian	Greek (modern)	Arabic	Chinese
°*as-similatio*	1828[31]	*assimilation*	*assimilation*	*Assimilation*	að-lögun ('onto-form')	*ассимиляция*	*ἀφ-ομοίωσι*[32]	mumāṯila ('similarity')	語音同化 yǔyīn tóng huà ('phonetic same convert')
morphema	1895	*morphème*	*morpheme*	°*Morphem* < Gk.	myndan ('built'; < ad mynda, 'to build'), *morfem*	*морфема*	*μόρφημα*	*mūrfīm*, maqṭaʿ ṣarfī ('excerpt morphological')	词素 cí sù ('word component'), 语素 yǔ sù ('language component')
°: 4 1 *10* **1** 0		°: 0 1 *9* **2** 0	°: 0 1 *9* **2** 0	°: 3 0 *8* **1** 3	°: 0 1 *0* **0** 11	°: 0 4 *4* **1** 3	°: 5 4 *8* **0** 0	°: 0 1 *1* **0** 10	°: 0 4 *0* **0** 8

31 Used in English by Stuart (1828: 51), and possibly already in the edition of 1813 (to which I had no access). The word is immediately clear for people acquainted with Latin, so it matters little in which language it was first used in the linguistic sense.

32 In Late Antiquity this means 'making alike', e.g. Clement of Alexandria for an assimilation to God. The linguistic use in Greek is a back-translation from the Latin.

For some of the terms considered, more context is needed. The word for 'force' in physics was calqued from Greek into Latin, and from there to the other languages, all of them using calques and a word expressing physical 'strength'; 'force' is derived from the Late Latin abstract *fortia*,[33] which in the vernacular languages replaced *vis* altogether. 'To distil' is a different case: although it was also calqued from Greek into Latin, most other European languages then just took over the Latin word as a loan. More recent coinings such as 'molecule' or 'morpheme' are even more often taken over as mere loanwords. For the formation of the words in the other languages, it mostly matters little whether a word was first used in Latin, French, or English, as in all these cases Latin constituents were normally used. On the whole, French, English, German, and Russian – all of which were important languages for scientific publications throughout the twentieth century – often use very similar terminology. Icelandic, Modern Greek, and often Arabic, all of which hardly fulfilled this function, disagree more often. In some cases, Arabic also uses loans (such as *uksiğin*). In ordinary speech, Icelandic hardly ever admits loanwords, but in chemical nomenclature it cannot avoid some; compare *sýker* and *glúkósi*.

In the case of Russian, it must be remembered that it only became a language of scientific communication toward the end of the nineteenth century. Although it can form new compounds rather easily (кислород, переходный) it often uses loanwords. Modern Greek only very rarely adopts Latin words; whenever possible it takes a classical (or classical-sounding) equivalent for new Latin concepts (such as νωθρότητα; the same is true in other fields: 'autmobile' becomes αὐτοκίνητον), but new, well-formed Western coinings from Greek constituents are taken over readily (ὀξυγόνον). Loanwords seem to be more common in the natural science of chemistry than in the human science of linguistics. Among the linguistics examples, Chinese, Icelandic, and Modern Greek use no loanwords at all, Arabic only one (*mūrfīm*).[34]

The more recent a scientific term is, the harder it may be to find a translation for it in languages that are not among the major scientific languages. Even the largest dictionaries in existence may not contain the words for 'to undergo ablaut' or 'acetic acid'. In linguistics, terms for phenomena that only exist in some language groups may not have a fixed name in languages that lack them: I found no certain corresponding Arabic terms for 'undergo ablaut', 'sound law', and 'stem vowel'. The Arabic language's translations amount to a description that

33 See Stotz (1996–2004: VIII, §12.7 = vol. 4, p. 39 with n480).

34 Compare the similar comparative list between many more terms of the natural sciences, but only from Germanic and Romance languages (English, German, Swedish, French, Spanish, and Italian) in Savory (1953: 160–162).

sounds rather too general (e.g. *tanāwaba ḥarakatan*, 'alter vowel'). Similarly, Chinese uses a cumbersome 元音变换 ('phonetic same convert') for our 'assimilation'. Thus, it becomes clear that even today not all sciences are equally international. For languages that do not borrow, such as Icelandic or Chinese, the trick is to nevertheless use one-to-one relationships with the international *Begriffsgemeinschaft*.

§5 The sample used in this chapter is admittedly small, but nonetheless it is hoped that it can illustrate some interesting trends. The path of least resistance for a language is certainly to take on scientific terms as loanwords, possibly adapting their phonetics slightly. English or Russian do this often in the above sample, but it can be done in much more extreme ways, as for instance Indonesian does. It takes on scientific words very widely, from whatever source lies at hand (*gravitasi, oksigen, predikat, ablaut, vokal*, …). The disadvantage of this approach is, of course, that the new words are not integrated into the language, their structure is not immediately clear to speakers, and they cannot easily be further modified, so they tend to remain erratic blocks in the fabric of the language in question. In this respect, it would seem to be a much better strategy to make calques (as Icelandic and Modern Greek often do), or even to build the concepts from existing ones, independently of how this was done in the source language, as Chinese usually does. A good example is 乙酸 *yǐsuān* ('second acid'),[35] which is much more logical than our historically evolved 'acetic acid'. The disadvantage in this is the enormous effort the linguistic community has to undertake to enable it, and indeed this approach seems to be rare among languages. German is an example of a language that uses both strategies, sometimes even for one and the same concept (*Gravitation* vs *Schwerkraft*, etc.). But it seems that German has done this in a much less confident manner since the two lost World Wars, especially in the natural sciences, in the case of which German seems to have resigned itself to being replaced by English.

Comparing the two sample sciences, striking general differences can be observed: whereas the chemistry vocabulary comes by and large from Latin (sometimes through French or English), that of linguistics tends to stem from Greek or German. The former science is also much more global: the two non-European and non-Indo-European languages Arabic and Chinese have developed clearly visible strategies for incorporating chemical terminology from European chemistry; this is much less the case in linguistics. In contrast, Icelandic has a harder time with the chemical terminology than the linguistic one. The latter is based on Greek or

35 i.e. the organic acid with two carbon atoms.

German compounds which Icelandic can very easily reproduce. The only case that might not be one-to-one is the Icelandic *hljóðskipti*, literally 'sound shift' but apparently used for the different concept 'ablaut'. Chemistry, especially due to the enormous size of its vocabulary (e.g. the many compounds in organic chemistry), made Icelandic unfaithful to its philosophy of not taking over foreign words: *nikkel* and *glúkósi* are still relatively harmless cases. 'DNA' is only translated halfway, as *deoxý-ríbósa-kjarn-sýra*, which is, however, still usually addressed in its abbreviated English form as *DNA*.[36]

The historical development of languages into carriers of European science has not yet been studied comparatively. Although in the nineteenth century many smaller European languages started to acquire their scientific vocabulary, they have on the whole not been able to produce important publications for the simple reason that the leading scientists cannot be expected to read more than three or four languages. After a fight for scientific hegemony among Italian, French, German, and English, and quite soon only the latter three, this struggle, which forced scientists to learn more languages than during times of Latin hegemony, when one was enough, seems to be coming to a temporary halt now, with English emerging as 'winner'.[37] Most natural sciences publish serious contributions only in English now. In Classics and in Mediaeval Latin studies, we are still in the comfortable situation that all of the four mentioned languages are equally acceptable for important publications, although there does seem to be a growing tendency for native speakers of English to stop reading publications in other languages, a fact that may ultimately force the others to switch to English as well.

Despite this tendency toward monolingualism in science, all languages used at least as the official language of a state or region, thus for instance in schools and administration, have had to learn to express the fast-growing international scientific terminology. The strategies have depended on the language: smaller Indo-European languages have followed their closest 'major' relatives; non-Indo-European languages with large resources and a strong sense of their own culture will do something similar to what we have seen the Chinese do; those that do not (the majority) will more likely follow an Indonesian strategy. It would certainly be interesting to study this in further languages, but this is clearly outside the scope of the present study concerned with Latin.

36 As at https://is.wikipedia.org/wiki/DNA.

37 This book is an example of this: half a century ago, I would certainly have written it in German, two centuries ago in Latin.

Developments in the twenty-first century

§6 In some fields, new coinings are still expected to have a fully Greek or Latin name in the twenty-first century. Above (chap. 15 §5), botany was briefly discussed in this respect. In astronomy newly discovered features, for instance on the former planet Pluto, still receive Latin names, such as *Cthulhu regio, Hillyra montes* (discovered by NASA in 2015). More frequently, it is still the rule to form new scientific words from Greek and Latin components, especially in English, which is so deeply rooted in Latin and French that Latin coinings come very naturally to speakers. A similar phenomenon was described by Henry Bradley for English in general – that 'the whole Latin vocabulary' had become 'potentially English' (1904: 94–95):

> It has come to be felt that the whole Latin vocabulary, or at least that portion of it which is represented in familiar classical passages, is potentially English, and when a new word is wanted it is often easier, and more in accordance with our literary habits, to anglicize a Latin word, or to form a compound from Latin elements, than to invent a native English compound or derivative which will answer the purpose.

From English these new terms tend to move to other languages, nowadays sometimes even into Chinese. For instance, fullerenes – a recently discovered form of carbon that is named after Richard Buckminster Fuller and thus does not bear a Graeco-Latin name – are called 富勒烯 *fù lè xī,* where 烯 *xī* means 'alkene' and thus describes the fact that there are double bonds in fullerenes, but the first two characters are phonetic. Thus, something like a scientific koine based mostly on Latin and Greek constituents comes into existence, from which scientific English terms can be appropriated easily by most other languages.

A similar trend existed among Latin humanists, who incorporated Greek terms and phrases into their writings very frequently and usually without any explanation. Within Europe, an unusual intellectual cohesion, largely thanks to the classical languages, can be observed: besides the mentioned related languages (Romance, Germanic), later additions such as Slavonic and unrelated languages such as Hungarian, Finnish, or Basque have also shared in this largely similar intellectual milieu or *Begriffsgemeinschaft*; only the comparison with distant non-European languages such as Arabic and Chinese makes clear that this milieu is by no means a matter of course, although the past century with its overwhelming success of European science largely brought such other language communities into a situation in which they could no longer ignore it. Quite in general, much in our modern languages is built out of jetsam and flotsam from Latin and Greek, which has often changed its meaning decidedly and is usually used unconsciously by speakers. Often the constituent parts become hardly recognisable, as some random examples from vehicle names show: 'tandem bike' with no obvious relation to the Latin particle *tandem*; the French *automobile* (from questionable Neo-Latin *automobilis*) turning into German *Auto*, but Swedish *bil*; or the case ending of *omnibus* turning into 'bus'.

Despite this, over the past few centuries a mostly one-to-one correspondence for scientific terms among all major languages has evolved. This is the deeper reason for the easy translatability postulated by some scholars and mentioned earlier (chap. 16 §4). Scientific terms thus largely function like proper names, even those that are not nouns (verbs may be avoided in translation, as German *ablauten,* English 'undergo ablaut' indicates). In other language domains, this is not at all the case. Examples of words that cannot be translated between pairs of languages without lengthy explanations abound. A few that can be mentioned for the closely related languages German and English are *Fingerspitzengefühl*, *gönnen*, or *artgerechte Tierhaltung*, and 'obnoxious', 'posh', or 'mind'. This finding indicates that the success of modern science in everyday life led to a claim to international and intercultural validity, thus to being, as much as possible, independent of the quirks of individual languages. But in reality the contemporary language of science is very strongly based on Greek, Latin, English, and possibly some other European languages, and on our European *Begriffsgemeinschaft*. The modern scientific way of thinking is still today decidedly Graeco-Latin.

24 On the relation between science, culture, and language

> En la genèse d'une doctrine scientifique, il n'est pas de commencement absolu; si haut que l'on remonte la lignée des pensées qui ont préparé, suggéré, annoncé cette doctrine, on parvient toujours à des opinions qui, à leur tour ont été préparées, suggérées et annoncées.
> 'In the genesis of scientific doctrines, there is no absolute beginning; as far back as one may go in the line of thought that prepared, suggested, and announced a doctrine, one always arrives at opinions which, in turn, have again been prepared, suggested, and announced.'
>
> Duhem (1913–1959: 1:5)

§1 This final chapter will try to unite several of the many threads in this book. A first part will consider whether one can and should speak of science outside the Greek cultural horizon (§§1–2). This leads to the point that methodology and scientific language develop in tandem for a culture on the brink of becoming scientific. Various forms of a language of nascent science from old cultures outside the Greek horizon (§3) will be compared to Greek (§4). The importing of the Greek kind of science into one of them – Latin – will then by highlighted and the main linguistic problems the translators faced discussed (§§5–8); they quite naturally led to a type of Latin similar to that of scholasticism (§9).

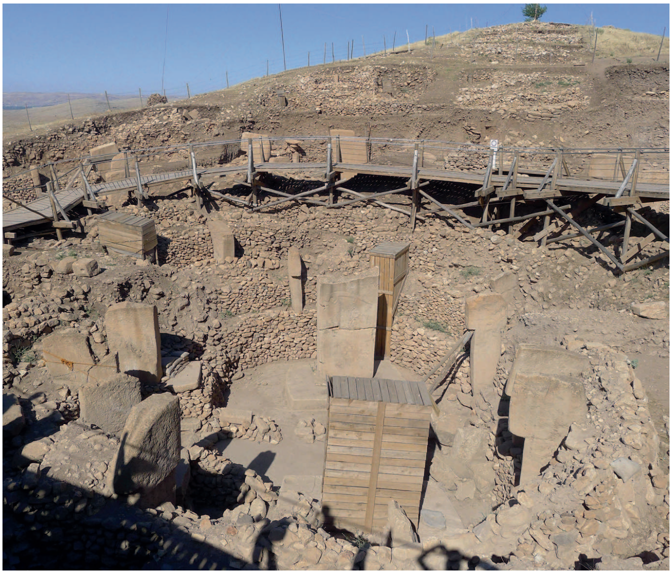

Fig. 49: Göbeklitepe site, near Urfa in Eastern Anatolia. The preserved, erected, and engraved stone pillars weigh up to 20 tonnes. Author's picture (2012).

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Science a Greek invention?
In order to embed the diaglossic study of the term ‘science’ and the proposed criteria for it (chap. 4) into a larger context, we consider the question of the origin of science. Even a cursory glance at the modern literature on this question will quickly lead to the impression that the answer to this question largely depends on one’s definition of ‘science’. Indeed, it has been shown in part 1 of this book how a notion of ‘science’ developed slowly over the past two and a half millennia in the Graeco-Latin world and what can pass as science and what cannot is still in flux today. Now, should one speak of science before the Greek authors studied above (chap. 7 §§2–3)? We know of prominent feats of human material ingenuity since at least twelve thousand years ago, when the temple-like structure at Göbeklitepe[1] (fig. 49) in Eastern Anatolia was built, for which the cooperation of a great number of people in an organised way was obviously necessary. Only for less than half the time span since then do we have written documents (since ca. 3000 BC in Sumer and Egypt), and for only about half of this time in turn is there cultural continuity in Europe (beginning in post-Dark Age Greece).[2] In other words, insight complete enough for there to be a hope of tracing the relevant developments more or less adequately is available only for the past two and a half millennia. The development of human crafts, technology, philosophy, and stricter kinds of science was obviously a gradual process over the entire time span in question. If one sees science as a general problem-solving activity,[3] then obviously it is much older than the Greeks. But it would seem that it makes sense to have several terms for such activities in this long time span of human mental development at one’s disposal. Whereas the builders of Göbeklitepe certainly used ‘craft’ (*ars*), it is hardly appropriate to call what they had at their disposal ‘technology’ – a word that does, however, spring to mind in the case of the builders of the Egyptian pyramids in the first half of the third millennium BC. And theoretically minded ‘science’ consisting of feedback loops of unbiased observation and the search for underlying theoretical patterns (see chap. 4) is another matter again.

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1 On this site, see Schmidt (2006).
2 Timeframes are comparable for China and India, the two other regions with written cultural continuity of a similar time-depth.
3 As, for example, D’Ooge (1926: 5–6) proposes in his translation of Nicomachos of Gerasa: not just ‘the systematization of the sciences achieved by the Greeks, together with the process of logical demonstration’ should be called science but instead science is taken as generally concerned with ‘problems involved in comprehending the universe’. This approach is common among French authors as well, where the word *science* covers both ‘science’ and ‘knowledge’. More examples were quoted in chap. 4 §3 above.

Now, given that we possess quite extensive information about Mesopotamian and Egyptian technical writing, it can be compared to the Greek kind of science that developed between the sixth and fourth centuries (discussed in chap. 7). Among scholars of Mesopotamia, the point of view that Mesopotamian culture, despite cultivating many skills in many of what would later become scientific disciplines, must be termed 'pre-scientific' still seems to prevail;[4] the reason for this is that it did not try to understand systematically and methodologically the phenomena that are often meticulously described. Thus, the initial euphoria about pre-Greek science expressed, for example, by Paul Schnabel (1923) had to be put into perspective.[5] Mesopotamian 'mathematics' was more than mere calculating; it can be described as algorithmic in concrete number examples, leading to a quite advanced art of calculation. A kind of oracular and etymological 'science' evolved from the polysemy of the cuneiform script,[6] and a similar search for hidden meaning in the stars led to astrology, for which rather 'scientific' astronomical tables were prepared. In general, people have referred to *Listenwissenschaft* ('science in the form of lists') in the ancient Orient (since Soden 1936). All of these branches akin to science were already flourishing around 2000 BC.[7] Similar points could be raised for ancient Egypt, especially in its *Wissenschaft des Jenseits* ('science of the beyond'), meticulously describing the topography of the next life.[8]

It is now beyond doubt that the Greeks acquired a lot of practical and technical knowledge from the Mesopotamian and Egyptian cultures, but it seems that both lacked rigorous, theoretical, methodological approaches subjecting their knowledge to unbiased testing.[9] Thus, the Babylonian art of calculating lacked the

4 Neugebauer: 'Babylonian mathematics never transgressed the threshold of pre-scientific thought' (1970: 48). Similarly van der Waerden (1954–1974, 1966). New findings may, of course, change this conclusion. More recent publications seem rather to avoid such 'metaphysical' questions.

5 Discussed in Hunger & Pingree (1999).

6 See Bottéro (1987); for example, he speaks of 'la "dialectique" graphique' (180–194). By the way, a similar dialectic still exists in the Chinese writing system today.

7 A good overview of technology, culture, magic, medicine, calculating, the status of writing, books, libraries, and many other things in Egypt (section 1) and the ancient Near East (section 3) is provided in Petruccioli (2001–2004:vol. 1). Unfortunately, the question of what science is, is avoided in this work.

8 Hermsen (1991: 31). See further the collection of important sources in translation in Clagett (1989–1999).

9 As Crombie (1996: 440) puts it: 'In Western terms they [cultures before and alongside the Greeks] had no system of rational science.' Clagett (1955: 19–20) had already reached similar conclusions, but his statement that '[a] history of science of this [pre-Greek] period clearly confirms the empirical origin of science' rather puts the cart before the horse – at least if one agrees to see science as the interplay between 'theory' and 'empiricism'.

idea of proof[10] and used no general, theoretical formulations.[11] More theoretical Mesopotamian texts do appear, but only in the last two centuries before Alexander, thus in the same timeframe as in Greece.[12] Unfortunately, and despite the great advances achieved by West and Burkert in the past few decades,[13] our knowledge about the Greeks' debt to their predecessors is still rather sketchy, making it hard to gauge what we are to expect early Greek thinkers in Asia Minor (such as Thales and his disciples) to have learned from Assyrian and other Mesopotamian lore. In some cases, men who may have served as links between the Orient and Greece can still be traced – for instance, the Greek physician Democedes of Croton, who worked at the Persian court in the sixth century.[14] But above (chap. 7 §2), it became clear that we should also consider these earliest Greek 'pre-Socratics' as pre-scientific, and that we could trace the accumulation of the necessary ingredients for 'science' in fifth-century Greece quite well, but not earlier.

§2 Some of these ingredients of scientific endeavour seem to be human universals, for instance the desire to produce elaborate classification schemes for the things in one's surroundings (*Listenwissenschaft*).[15] In ancient cultures, one also commonly finds the phenomenon of the 'wise man' who tells other people 'the truth' he has received by some special faculties available only to a few chosen men like him. The Milesian philosophers with their fanciful and apodictically formulated cosmologies that are often completely incompatible with one another are good examples. A little later Empedocles, who claims to be of divine origin,[16] or Heraclitus, who speaks in riddled aphorisms, are further examples of typical behaviour of wise and divinely inspired men.[17] Ancient India knows similar sages in

10 Lloyd (1979: 230).

11 Lloyd (1987: 44) rightly adds that the Greeks tend to overdo it: 'they often, it may seem to us, fail to recognise the limitations of what they had achieved or of what they could hope to achieve, [...] the answers they proposed are vulnerable, if in different ways, to criticisms similar to those they themselves brought against earlier beliefs.'

12 Examples in Hunger & Pingree (1999: 203–212). Several late Babylonian astronomers are mentioned by Strabo (*Geographica* XVI.1.6, ed. Radt, vol. 4, p. 282). Allen (1989) develops an idea voiced by Assmann: that Akhenaten's (d. 1336 or 1334 BC) new Sun-religion would rather have developed into a kind of pre-Socratic study of nature than into monotheism, had it been successful.

13 Especially West 1997 and Burkert 2004.

14 Herodotus, *Historiae* III.131–138, ed. Wilson, vol. 1, pp. 317–322. Doubt has recently been cast on the historical existence of Democedes (Davies 2010).

15 On which see Lévi-Strauss (1962: esp. chap. 5). See §3 below on Chinese 'correlative thinking'.

16 Frag. D4 LM, line 4 = B112 DK.

17 See Meuli (1935) and his comparison of these wise men to Siberian shamans (see chap. 7 §2 above). Lloyd (1987: 87) presents literature on sages in the ancient Near East and India, contrasting the exoteric nature of wisdom in Greece.

the early Upanishads, which, incidentally, seem to have been composed about the same time those early Greek thinkers flourished. Unfortunately, close to nothing can now be traced about individual thinkers among them, though they are often mentioned by name. In China, Confucius (551–479 BC) and 'Laozi' (the presumed writer of the *Dàodé jīng* 道德经) could similarly be compared with the pre-Socratic philosophers. It would seem that philosophy tended to evolve out of such wise men's lore in various cultures; in contrast to science and although the term 'philosophy' itself is typically Greek, it does make sense to speak of Indian or Chinese philosophy before contact with the Greeks.[18] As Lloyd (1987: 49) stressed of the early Greek philosophers, they

> were wise men of a different kind, unlike the old seers in important respects, though again much closer to them in others than aspects of the self-image they projected would lead one to expect.[19]

It has been described how Plato and Aristotle strove to make the word ἐπιστήμη mean an especially rigid and certain kind of knowledge (chap. 7), one that knows the 'why', not only the 'how', of something. Already before them, some authors started to do what would become science, and after them in Hellenistic times, sciences like geometry, astronomy, zoology, botany, and textual criticism and their inventors are for the first time clearly discernible. As Schadewaldt (1960: 871) put it:

> Man könnte es, von der übrigen damaligen Welt her betrachtet, vielleicht eine Marotte nennen, was diese Menschen, vor allem vom sechsten Jahrhundert v. Chr. an, trieb und bewegte, eine Marotte freilich von weltumwälzender Bedeutung. Da versteiften sich diese Männer darauf, zunächst und zuvörderst nicht so sehr vom Bedürfnis und den praktischen Zwecken auszugehen (die auch sie recht gut zu verfolgen wußten), sondern sich zunächst und zuvörderst einmal sich für die Sache selbst zu interessieren, für das Es selbst der Dinge auf allen Gebieten: z. B. nicht bloß zu zählen und zu rechnen, um etwas zusammenzuzählen und auszurechnen, sondern deswegen, weil hinter dem Rechnen und dem Zählen das überaus interessante 'Es selbst' der Zahl steht, was weiterhin zur Mathematik führt. Und so auf allen anderen Gebieten von Natur und Gesellschaft [...].
> 'Looked at from the point of view of the rest of the world at that time, one could perhaps call what drove and moved these people, especially from the sixth century BC, a whim – a whim, admittedly, of world-shaking importance. These men insisted, first and foremost, on being

18 Treated e.g. by Zimmer (1969) for India and Mou (2009) for China. Possible terms in these languages for 'philosophy' are *(tattva)vidyā* ('(essential) knowledge') in Sanskrit and 哲 *zhé* ('wisdom') in Chinese. Contemporary Chinese uses 哲学 *zhéxué* to translate our 'philosophy'. See §3 below for more on 学.

19 He further points out that theirs 'was a wisdom committed to different procedures of discovery and of the justification of belief' (Lloyd 1987: 335).

> not so much interested in the needs and the practical purposes (which they knew how to pursue quite well), but rather in the thing itself, in the "per se" of things in all fields, for example not only counting and calculating in order to add up and calculate something, but because behind the calculation and the counting there is the extremely interesting "per se" of number, which leads to mathematics. And so too in all other areas of nature and society [...].'

In the same vein Lloyd (1979: 224) stated:

> We saw [...] that much of the strength of Greek science lies in its formal dialectical and demonstrative techniques, and that the definition and analysis of the axiomatic, deductive system, together with the development of the application of mathematics to the understanding of natural phenomena, occupied a considerable and productive intellectual effort.

But, it has also became clear (see chap. 3) that there was no unambiguous term for 'science' yet; the less strict meanings of ἐπιστήμη and *scientia* remained in use in both ancient languages. English and German today would differentiate the two meanings as 'knowledge' (*Wissen*, *Erkenntnis*) vs 'science' (*Wissenschaft*). The development of a concept 'science' was followed in outline in part 2 of this book; by the mid-twelfth century the Aristotelian conception of science had become generally known as *scientia* in Latin Europe, from which our understanding of 'science' follows organically.[20] Thus, the motto quotation by Duhem remains valid, although this does not mean that we should refrain from trying to conceptually structure the continuum of developing thought. It is obvious that the origin of science cannot be found in one single event (Lloyd 1979: 231); several factors together, most of which also occurred elsewhere, had to be combined in the time of Plato's Academy and especially in Aristotle's own school for a scientific frame of mind or *Denkstil* to establish itself definitively. These factors are what we tried to list as criteria for science above (chap. 4). Especially relevant for the beginnings are rigorous and conscious use of language (leading to the science of logic); the idea of proof, itself based on logic and mathematics (which therefore had to exist at least *in nuce* before); the necessity of a method in principle comprehensible to anyone;[21] critical examination of new theories (although many early Greek thinkers – including Aristotle – were better at this when dealing with their opponents' theories than with their own); and the gathering or observing of facts to be used in a coherent manner. As has been seen above, in the fifth century[22] a considerable

20 It had done this already several centuries earlier in Arabic as *ʿilm*.

21 Termed 'self-conscious methodology' by Lloyd (1979: 233).

22 The question of why this 'scientific spirit' developed precisely in fifth-century Greece is discussed at some length in Lloyd (1979: esp. 236–264), and again in Lloyd (2000), who considers sociological factors that separate classical Greece from other early cultures, especially public debate (11), and in general political and social conditions. A society's openness to and appreciation of in-body of new knowledge in astronomy, geometry, and other future scientific fields accumulated. Besides, written records available to a large community facilitated the growth of science significantly, although this does not seem to be a *conditio sine qua non*.[23] We will now compare some cultures outside the Greek horizon and their approaches to learning, scholarship, and technology.

Nascent science outside the Greek cultural horizon

§3 In Hellenistic times, this Greek scientific frame of mind seems to reach a 'critical mass' in society. It spreads throughout the Greek-speaking world and produces the beginnings of many sciences and hand-in-hand with them often also technological advances. It will also spread to other cultures that come in contact with those Greeks. The Arabs and Latins of later times are the best-known and most fruitful examples. In contrast, cases of similarly scientific endeavours outside the reach of Greek culture are hard to find; indeed, the interplay of observation and pattern-seeking so typical for science is found at best *in nuce*. The most promising such cultures are the Chinese and the Indian ones, the latter before extensive contact with the Greeks after Alexander the Great's campaign. As mentioned, early (pre-Han) China certainly had its share of wise men, who in some cases rather strongly resemble their Greek and Indian counterparts.[24] In China we find technical texts on various topics, works on statecraft, philosophical disputations, or 'mathematics'. There was even an institution with the potential to become a scientific school, the Jìxià academy (稷下学宫) in the state of Qí (齊) in present-day Shandong province, which operated during several generations but ended in 221 BC when Qí was conquered by Qín (秦). Not much is known about the institution itself, but it is clear that scholars from other Chinese states also met there to discuss and that there was Qí state patronage.[25] Famous intellectuals frequented it, such as Mencius, Xun Zi, and Zou Yan, who had the clearest interest in 'nature' among them. Instead of science, what has been called 'correlative think-

novation is certainly also important; in Greece there was a minor literary genre on the πρῶτος εὑρετής of discoveries (on which see Kleingünther 1933).

23 Indian grammarians were able to do without it. Pāṇini developed his scientific grammar apparently without writing it down (writing was not yet in use in India at that time) and handed it down among his pupils by having them memorise it. Thus, the argument one encounters occasionally, that science needs literacy, is not strictly true.

24 For an introduction, see Harper (1999), especially on Mohist 'science' (813) and on recently rediscovered technical manuscripts from the Warring States period (475–221 BC; 819). See Levi (1988) on Chinese pre-Han 'sophists'.

25 See Nivison (1999: 769–770).

ing' evolved from these early Chinese intellectual currents: *yīn* vs *yáng* (陰陽) and the five 'elements' (*wǔxíng* 五行), leading to a school founded by Zou Yan,[26] sometimes questionably labelled the 'School of Naturalists' but more correctly that of Yin-yang (*Yīnyángjiā* 阴阳家). Typically, lists of correspondences, for instance of elements, colours, and rulers, are made that resemble Western hermeticism (chap. 12 §5). Nivison (1999: 810) concludes:

> [c]orrelative thinking seems scientific but is actually close to the intuitive aesthetics of music and dance; it tended to crowd out any possibility of a vigorous development of genuine science in ancient China.

Among the more technical 'sciences', the art of calculation was quite developed at least by early Han times (202 BC–AD 220), as demonstrated by works like the *Nine Chapters* (*Jiǔzhāng suànshù* 九章算术).[27] But they again lack the idea of proof and rather resemble the Mesopotamian 'mathematics' discussed above (§1). China clearly had its indigenous kind of learning, but little of traditional Chinese learning that has survived to modernity (Chinese medicine, *fēngshuǐ*, the *yìjīng*, …) would be recognised as scientific by modern scientists, hardly even as remote predecessors of science.

In Chinese, 'science' can be addressed as *xué shù*, a term made of *xué* (学 'learning, knowledge, art'), whose basic meaning 'to learn' resembles *doctrina* (1.3 §8), and *shù* (术 'method, technique, art, systematic learning', a character related to 行 *xíng*, 'go, move, perform'). The term can be compared to Roman *disciplina* (1.3 §3); either of these two characters can also be used individually with a similar meaning. Further combinations confirm that the meaning is broader than our 'sciences', for example 魔术 *móshù* ('magic', literally the 'art of demons'), or 文学 *wénxué* ('literature', literally 'language learning'). The modern Chinese term for 'sciences', *kēxué* (科学 'branches of learning'), stems from the nineteenth century and was formed in imitation of Western 'science' and adds the character 科 *kē* ('division'), thus emphasising the edifice of scientific fields.[28]

India also developed some 'sciences' before sustained contact with the Greeks, most notably grammar/linguistics – Pāṇini's (probably fifth century BC) grammar reached a level of understanding of the structures of language that the

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26 Unfortunately, his works are lost. Our best source is the Han historian Sima Qian.
27 Specialists see them as home-grown, thus unrelated to Greek mathematics. Edition: Chemla & Shuchun (2004). On Chinese mathematics in general, see Martzloff (1988).
28 See Wang Hui (2011: 46–47). Lloyd & Sivin (2002) compare Greek and Chinese conceptions of 'science'. For an encyclopaedic history of science in China, see Chemla (2001). Kim (1982) explores why premodern China did not have a 'Scientific Revolution'.

West did not reach before the nineteenth century[29] – and other 'sciences' in the context of ritual and holy texts. Very little is known about Pāṇini or his way of working and of forming a school of thought that would hand down his grammar. We know that he was active in Śalātura in Gandhāra (some eighty kilometres north-west of Islamabad, at least nominally part of the Persian Empire then).[30] The closest Sanskrit equivalent for 'science' is *śāstra* (neuter), but it has a much broader range of meanings, including 'precept, rule, teaching, manual, compendium, religious or scientific treatise'[31] – also somewhat similarly to Latin *disciplina*. This word is used to designate all sciences (in the broad sense of *Wissenschaft*) from around the turn of the Christian era.[32] It is derived from *√śas* ('instruct, command, punish', of unclear further kin). India's early sciences apparently evolved from the pursuit of ritual, which is for its systematic nature called 'ritualistic science' by Staal (1996: 349–367); it is debated since when exactly ancient India also knew of such 'sciences' as *dharma-śāstra* (the study of law), *artha-śāstra* (the study of worldly life, roughly 'political science'), *kāma-śāstra* (the study of sex), and *śilpi-śāstra* (the study of mechanical arts).[33] In most cases, it is unlikely that these Indian branches of learning pre-date Alexander the Great and thus intense contact with the Greeks, but it is certain that Pāṇini did.

If the foundation of *śāstra* is taken to lie in ritual, and that of *xué* in Chinese correlative learning, we might say that *śāstra* and *xué* were hardly developed outside of India and China respectively, just as we say that ἐπιστήμη was hardly developed outside of the Greek cultural horizon.[34] The decisive difference is, of course, that ἐπιστήμη–*scientia*–'science' and its technology have turned the world upside down (for good and for ill) and become the international standard approach. Indian and Chinese scientists and engineers today study, teach, and apply modern, that is, Greek-based science like everybody else. The relationship between the concepts ἐπιστήμη, *śāstra*, and *xué* would be a rewarding topic to study more closely in order to see to what extent the meaning of these terms developed independently and convergingly. This is made difficult by the dearth of

29 On Indian grammar and linguistics, see Cardona (2001).

30 See Scharfe (1977: 88–89).

31 The meanings are given in shortened form from Monier-Williams (s.v.).

32 Thus Staal (2001: 615). The science of sciences (*śāstra śāstrānam*) in ancient India is linguistics.

33 For a summary of some of the text, compare Winternitz (1909–1920: vol. 3). See in addition Gonda (1973–1987), esp. Scharfe (1977) on grammar.

34 As Burnet (1920: v) puts it: 'It is an adequate description of science to say that it is thinking about the world in the Greek way. That is why science has never existed except among peoples who have come under the influence of Greece.'

early sources and by the intense contact that has existed between these three Euro-Asian cultural spheres for at least two and a half millennia.

A look at the language of the clearest case of science outside the Greek horizon may help to understand the relation between science, culture, and language better. Pāṇini's grammar is written in *sūtra* or aphoristic style. For instance, he says (*Aṣṭādhyāyī* I.4.101–102, ed. Boehtlingk, p. 42):

> *tiṅas trīṇi trīṇi prathamamadhyamottamāḥ |*
> *tāny ekavacanadvivacanabahuvacanāny ekaśaḥ ||*
> 'The three times three conjugational affixes [*tiṅ*] are third person, second person, first person;
> the latter [are] individually [called] singular, dual, and plural.'[35]

In short, this specifies that there are three persons and three *numeri* for any Sanskrit verb, as swell as their names. The 'scientific' (i.e. strictly valid) part of the science is formulated in a very strict manner, comparable to mathematical formulas. For non-experts, it takes a teacher or commentary literature to understand it.[36] This will remind the reader of the one Latin candidate discipline that largely developed more or less outside the Greek sciences: Roman law. We saw (chap. 7 §3) how statements were compressed in the Twelve Tables:

> *Si in ius uocat, ito; ni it, antestamino; igitur im capito.*
> 'If someone calls to court, one must go. If not, a witness is to be taken. Thus he is to be seized.'

This formulation could also be termed aphoristic: statements are brief, the syntax is simple, and indeed the persons involved often have to be adduced from the context. The language of the later jurists (chap. 7 §12) is much more complex; its logical structure (as that of Classical Latin in general) will be influenced by Greek logic and rhetoric. A text like the Twelve Tables requires external explanation by professionals. Indeed, in later times the Tables were often treated by jurists in commentaries; these lost commentaries can be suspected to have been modelled on Helle-

35 Thus a literal translation. An explanatory one would be much longer and might look like this: 'The three triads in both the sets Parasmaipada and Atmanepada, of conjugational affixes (comprised under the general name tiṅ, a pratyâhâra formed of the first and last of them, viz., tip and mahiṅ) are called, in order, lowest (3rd person of European Grammar), the middle (2nd person), and the highest (1st person). These three triads of conjugational affixes, which have received the name of Lowest &c., are called (as regard the three expressions in each triad) severally "the expression for one" (singular), "the expression for two" (dual), and "the expression for many" (plural)' (http://panini.phil.hhu.de; project leader: Wiebke Pedersen).

36 Details from Cardona (2001: 743–752).

nistic commentary literature. The same happened to (and preserved) Pāṇini's grammar: we have written commentaries since at least Kātyāyana (second century BC). Some early Greek 'scientific' texts also resemble these two aphoristic examples, for instance those by Heraclitus or Empedocles. However, Classical and Hellenistic Greek science texts, in contrast, are usually in themselves understandable to the reader: thoughts are logically developed in detail. They were based on a relatively broad educated reading public – beyond a narrow and secretive school – interested in them. The decisive 'critical mass' for Greek science becoming a phenomenon of sufficiently wide interest to keep being cultivated and handed down accumulated in Hellenistic times. Later cultures, most notably the Arabs and the high mediaeval Latins, were able to take up this scientific Greek approach, which finally led to our modern science. A similar development could in theory also have happened in other cultures, outside the Greek cultural horizon, but it did not.

Linguistic structure of Greek science

§4 Now, how did the scientific Greek language we know from authors such as Aristotle and Euclid evolve? Above (chap. 4 §7), we proposed as characteristics of scientific language: (i) well-defined terminology, (ii) exactness and univocity, (iii) extendability and flexibility, (iv) perspicuity, (v) evidentiality and modality. Point (i) requires methodical thinking about language (as the sophists, Socrates, Plato, and decisively Aristotle did; see chap. 7); points (ii) and (iii) profit from a large and logically extendable vocabulary; points (iv) and (v) from clear syntax. Past scholarship, especially the German classical philologist Bruno Snell, stressed such characteristics as typical of the Greek language, thus predetermining Greek to become a vehicle of scientific thought. Snell (1946: 199) said:[37]

> Es ist [...] nicht abzusehen, wie in Griechenland Naturwissenschaft und Philosophie hätten entstehen können, wäre nicht im Griechischen der bestimmte Artikel vorhanden gewesen. [...] wie hätte man etwas Adjektivisches oder Verbales begrifflich fixieren können, wenn der

37 Snell's approach toward the Greek *Entdeckung des Geistes* has been very fruitful in German classical philology but has also been heavily criticised. Burkert discusses the situation lucidly (2001–2011: 8:277–292), concluding that much in Snell is strongly exaggerated due to his lack of acquaintance with the ancient Orient. Burkert in his review, on the other hand, would seem to similarly go too far in another direction by stating his rejection of concepts such as *Seele* and *Geist*. Apparently, Neugebauer (285) told him that he preferred Babylonian 'true' mathematics to the Greeks' tendency to mystify everything. As pointed out above (§1, quoting from Neugebauer), what the Babylonians did was studying the practical art of calculation, not apodictic mathematics (invented by the Greeks). This is a difference that is still crucial in university mathematics today.

bestimmte Artikel nicht die Möglichkeit geboten hätte, solche ‘Abstraktionen’ wie wir sagen, zu bilden?
‘It is [...] hard to see how science and philosophy could have come into being in Greece if the definite article had not been available in Greek. [...] how could something adjectival or verbal have been conceptualised if the definite article had not offered the possibility of forming such “abstractions”, as we say?’

We have seen above (chaps 21–23) that many a language can learn to express nearly anything in science, given the urge to do so and sufficient time. Nonetheless, it seems obvious that some languages have a long way to go to become vehicles of scientific communications – think of a language that has no words for numbers or no clearly defined subordination – whereas others can combine their own and foreign elements quite effortlessly. Today, every major language has been engineered to be able to express Western (i.e. Graeco-Latin) scientific thought to a large degree. Nonetheless, Snell certainly correctly observed the importance of certain features of the Greek language used by early Greek scientists, especially effortless compounding, easy and versatile creation of noun phrases with the article, and the creation of new but intuitively understandable words by pre- and suffixation.[38] Chapter 22 showed some of the difficulties Arabic and Latin had in adopting such traits when translating Greek science. As we live in a world colonised by Western technology and worldviews, the gap has become much smaller, and it may even be difficult today to imagine the difficulties Arabic or Latin translators grappled with when trying to import Greek scientific thought into their respective languages for the first time in the Middle Ages. Indeed, Latin scientific authors often complain about Latin’s perceived inferiority compared to Greek, for instance Kepler on the missing article (*Astronomia nova*, ed. Frisch, p. 146):

Durissima est hodie conditio scribendi libros mathematicos, praecipue astronomicos. Nisi enim servaveris genuinam subtilitatem propositionum, instructionum, demonstrationum, conclusionum, liber non erit mathematicus; sin autem servaveris, lectio efficitur morosissima, praesertim in latina lingua, quae caret articulis et illa gratia, quam habet Graeca, cum per signa literaria loquitur. Adeoque hodie perquam pauci sunt lectores idonei: ceteri in commune respuunt.
‘The conditions for writing books in the mathematical sciences are very hard today, especially astronomical ones. If you do not keep to the subtleties of propositions, doctrines, demonstrations, conclusions, the book will not be mathematical. But if you do, it will become extremely tedious reading, especially in the Latin language, which lacks articles, and that grace Greek has when it speaks with alphabetical variables. And besides, these days there are very few suitable readers; the others commonly reject it.’[39]

38 More details on these matters in Roelli (2018) and below.
39 *Litterarius*, 2: ‘alphabetisch’ (Ramminger, s.v.; consulted 6 December 2018). Kepler alludes to the Euclidean usage of addressing for instance a line as ἡ AB, which could be declined easily in Greek but not at all in Latin.

The fact that Latin cannot decline letter symbols, which works so nicely for Euclid, was clearly especially painful to mathematicians. Of course, care has to be taken that such evaluations of the 'fitness' of languages for certain purposes do not become mere language ideology, something very common in the time when Latin's heirs were quarrelling for supremacy.[40] Examples of authors 'proving' the inherent superiority of French (such as Joachim Périon),[41] German (such as Georg Friedrich Meier or Gottfried Wilhelm Leibniz),[42] or even Dutch (such as Simon Stevinus)[43] could be quoted. But the naturally occurring features of the Greek language certainly came in very handy for the expression of novel ideas by early Greek philosophers and scientists. We shall now take a closer look at what Latin authors did when importing Greek scientific thought.

The import of Greek science into Latin and modern science

§5 The influx of Greek ideas, and with them of linguistic adaptations into scientific Latin, has been seen in part 2 of this book to have happened in five stages (one of them a dead end).[44] In Classical Antiquity (i), philosophers such as Cicero and Seneca made Latin prose capable of expressing philosophical (mostly Stoic) or doxographic thought from Greek, although largely excluding Aristotelian scientific thought and terminology (such approaches continued to be practised exclusively in their 'native' medium, Greek). At the end of Antiquity (ii), Boethius tried to change this, and succeeded for logic (his translations of the *Organon* were used in schools all through the Middle Ages), but did not have time to tackle natural philosophy. During the Carolingian renewal (iii), John Scotus Eriugena's lonely attempt to incorporate Greek (neo-Platonic) thought into Latin thinking was of very limited success. Only the fourth (iv) and far wider attempt of the translation movement in the twelfth century, when the work was shared by many and spread across several centres, succeeded; it led to thirteenth-century scholasticism, which was heavily indebted to Aristotelian methodology and the translators' language. The last stage (v), in the time of the Renaissance, is different from the mediaeval ones in that many authors were again becoming directly acquainted with

40 Language ideology concerning the biblical languages during Baroque times has been studied by Roelcke (2014).

41 Périon (2003), linking it to Greek.

42 Meier (1763); Leibniz (1872c), discussed in chap. 11 §6 above. See further Strassner (1995).

43 A mathematician who purposefully wrote many of his works in Dutch and often invented new terminology on the way; see van der Wal (2004).

44 Excluding important influence in other areas, especially crucially in the Latin Church Fathers, whose Christian Latin is heavily indebted to Greek.

Greek, and many of them could and did actively read Greek works, as intellectuals did in Antiquity. But unlike in Antiquity, Western scholars and scientists did not usually write in Greek but kept using Latin, which had by then become well adapted to the task, although there are still occasional complaints about its poverty (like that by Kepler, quoted above). Of course, Greek influence continues to this day in the vernacular languages of science (see chap. 23). Figure 7 above tried to summarise these phases of Greek influence on Latin over time.

First attempts in Antiquity to take over science from Greek (by authors from Cicero to Boethius) did not initiate a large-scale Latin science movement that would (using Galen's simile) begin to walk on two legs. This happened only in the twelfth century, and it produced the scholastic Latin described above (chap. 11): it strongly relied on the logical structuring of texts, and on suffixation and relative clauses to cope with Greek nominalised phrases using the article and compounds. Puelma (1980: 146) points out some of the main difficulties Latin had to face when beginning to express Greek thought:

> Die Bedeutung dieses hochgesteckten Zieles Ciceros kann man ermessen, wenn man bedenkt, dass in der lateinischen Sprache nicht nur fast die gesamte wissenschaftliche, abstrahierende Terminologie fehlte, sondern auch eine Reihe gerade jener Elemente der Wort- und Satzbildung in ihr nur schwach oder gar nicht vorhanden waren, die für die Geschmeidigkeit und Leistungsfähigkeit der griechischen Philosophensprache Voraussetzung waren, so die Leichtigkeit der Präfix- und Suffixbildungen, die unerschöpflichen Möglichkeiten der Wortkomposition, die reichhaltigen Partizipialkonstruktionen, die so gut wie unbeschränkte Fähigkeit zur Substantivierung aller Wortkategorien durch den Artikel. Ausdrücke wie τὸ μὴ ὄν, τὸ παθητικόν, τὸ κατ' ἀναλογίαν καθεστηκώς mussten, wollte man nicht mit Fremdwort oder unverständlich wirkenden Wort-für-Wort-Wiedergaben vorliebnehmen, in mühsamer Versuchsarbeit durch Annäherungskonstruktionen des Lateinischen ersetzt werden, so dass das sprachliche *usitatum* gewahrt und doch das sachliche *novum* deutlich und verständlich wahrgenommen wurde.[45]
> 'The importance of this ambitious goal of Cicero can be appreciated when one considers that Latin not only lacked almost the entire scientific, abstracting terminology, but also that a number of precisely those elements of word- and sentence-formation that were prerequisites for the malleableness and effectiveness of the Greek philosophical language were only weakly present in it or not at all, such as the ease of forming words with prefixes and suffixes, the inexhaustible possibilities of word composition, the rich participial constructions, and the almost unlimited ability to substantivise all word categories using the article. Expressions such as τὸ μὴ ὄν, τὸ παθητικόν, τὸ κατ' ἀναλογίαν καθεστηκώς had – unless one wanted to settle for a foreign word or incomprehensible word-for-word renderings – to be replaced by approximate constructions in Latin in a laborious process of experimentation so

45 Poncelet (1957: 51), who studied Cicero's translation of the *Timaeus*, saw a further domain in which Latin could hardly adapt to Greek thought: the usage of prepositions, which are more ambiguous in Latin.

> that the linguistic *usitatum* was preserved and yet the factual *novum* was perceived clearly and comprehensibly.'

Translators who were not concerned about *usitatum* could translate into a Latin very close to the Greek original, as many twelfth-century translators, such as James of Venice, did (chap. 10 §6) using the *verbum de verbo* technique. For instance, *quod* or *hic* could be used as an article surrogate, but it can and would be argued that the result is neither Greek nor Latin.[46] A translation must not only be possible *in abstracto;* it must also be acceptable and comprehensible to its audience. The following sections look at what would seem to be the three most important Greek structures for scientific expression and how they could or could not be rendered in Latin.

The article

§6 The lack of articles may be Latin's most inconvenient feature for the expression of scientific Greek thought.[47] It will make sense to first provide some background about what articles are and what can be done with them. The implications and attempts to remedy the situation by Latin writers are then discussed. Himmelmann studied articles in various languages. He found that demonstrative pronouns apparently occur in all languages, but definite articles only in a few (1997: 1). All Western European languages acquired articles through grammaticalisation from demonstratives, through erosion and contextual expansion (2). Quite in general, articles arise from adnominal, grammaticalised local deictics (6), which, however,

46 As e.g. the Renaissance translator Leonardo Bruni did (chap. 12 §2).

47 Similarly Wieland: 'Ermöglicht wird diese Thematisierung der Funktionalbegriffe durch die auf den ersten Blick recht trivial erscheinende Tatsache, dass die griechische Sprache den bestimmten Artikel kennt. Daher ist es der griechischen Sprache leicht möglich – was in der lateinischen, wie Ciceros Übersetzungen zeigen, nur mit großer Mühe geht –, außer Dingen im engeren Sinne nicht nur Eigenschaften, sondern auch konjunktionale, adverbiale, pronomiale und vor allem präpositionale Bildungen, ja sogar ganze Sätze zum Subjekt von Aussagen zu machen und danach Termini zu prägen. Von dieser Möglichkeit hat Aristoteles wie niemand vor ihm Gebrauch gemacht' ('This thematisation of the functional terms is made possible by the fact, which at first glance seems quite trivial, that the Greek language has the definite article. Therefore, it is easily possible for the Greek language – in Latin, as Cicero's translations show, this is only possible with great difficulty – to turn into the subject of statements, in addition to things in the narrower sense, not only properties but also conjunctional, adverbial, pronomial, and above all prepositional formations, even entire sentences, and then to coin them as technical terms. Aristotle made use of this possibility like nobody before him'; 1970: 175). Examples are discussed on the following pages, basically τὸ + non-noun: τὸ + letter, τὸ + quotation, τὸ + adjectives (like ἀγαθὸν), τὸ + infinitives.

may acquire very different functions from those of a definite article (Himmelmann presents examples from South East Asian languages). Such articles seem to be emerging structures that are rather unstable within languages.[48] Joseph H. Greenberg (1978) formulated a 'cycle of the definite article': beginning with a demonstrative, through a stage of a grammaticalised article, to a mere noun marker, and then to zero. Knowing that articles are not very common and not very stable, it is a very conspicuous fact that all major Western and Central European languages have two articles at their disposal today, one indefinite ('a', *un, ein*, etc.) and one definite ('the', *le*, *der*, etc.). Even Modern Greek added an indefinite one (ένας, μία, ένα) to its repertoire.[49] We can speak of an article *Sprachbund* in Western Europe. The definite articles grew (as expected) out of demonstrative pronouns; the indefinite article tends to be a form of the word for one ('one', *un, eins*), thus showing its nature of having to do with one object out of a potential multitude.

There are subtle differences between the articles of these different European languages, and it is impossible to define one sole rôle these articles share. Thus, it will be best to identify various nuances the article can add to a given word or phrase. The Soviet scholar Admoni (1972: 172) attempted exactly this for the German article, whose functions are according to him that (i) it provides information about a noun's category of being countable or not; (ii) it can individualise or generalise a noun; or (iii) it can show the definiteness or lack thereof of something, thus differentiating facts already known from such that are not.[50] It would seem that at least two more functions should be added to the list: the article can function (iv) to determine the case and number of indeclinable words, such as foreign words or symbols in German (e.g. 'die Exponentialfunktion *des* 2^x', where English would use a preposition: 'the exponential function of 2^x');[51] and (v) as a noun-phrase marker, although contemporary German tends to see this as stylistically ugly when it gets too long (e.g. '*das* Heute-morgen-spät-nach-Hause-Kommen', '*the coming home late this morning', which nonetheless remains a grammatical

48 '[...] besteht die zentrale Hypothese dieses Buches darin, dass syntaktische Struktur ein emergentes Phänomen ist, also nicht von einem universalen Strukturschema für nominale Ausdrücke auszugehen ist' ('[...] the central hypothesis of this book is that syntactic structure is an emergent phenomenon, i.e. a universal structural scheme for nominal expressions cannot be assumed'; Himmelmann 1997: 11).

49 Besides Latin, the exception to this rule is Russian (and many other Slavonic languages), which to this day does not have any type of article.

50 Similar lists can be found in standard works such as Vater (2002): definiteness (anaphora, deixis, larger situation), quantification, genericness. The most important function in our context, that of marking noun phrases, is not mentioned there either.

51 This is also possible in German; the difference is the same as using or not using an article (e.g. determination).

and understandable German utterance). This is the main point in our context: the article can turn any utterance into a new functional 'noun' that can be used in any function in the sentence or can be referred to as a single entity. This function exists in English, which can for instance say 'the reviewers' hostile criticising of the play',[52] a noun phrase that can in turn be inserted into many kinds of clauses as if the entire construction were but one single noun. But Greek and German can go much further than English with such constructions, as the following example from Pseudo-Dionysius the Areopagite (*De mystica theologia* 1.3, ed. Heil & Ritter, p. 143) shows. He is speaking of the first cause:

- διὰ <u>τὸ</u> πάντων αὐτὴν ὑπερουσίως ὑπερκειμένην <u>εἶναι</u>,
- <u>*hoc*</u> *omnibus eam supersubstantialiter superjacentem* <u>*esse*</u> (trans. Hilduin, ninth century),
- *ob suam super omnia sublimitatem et praestantiam* (trans. Halloix, seventeenth century),[53]
- 'by <u>its</u> <u>being</u> superessentially positioned above all [things]' (my trans.),
- 'durch <u>ihr</u> gegenüber allem überseinderweise darüberliegend <u>Sein</u>' (my trans.).

German and English here replace the article with a possessive pronoun which takes over its function.[54] But Latin cannot imitate such constructions. Hilduin tries to use *hoc* as an article substitute, which, however, is a solution that was never accepted by Latin language purists. The normal solution Latin will use in such cases is well illustrated by Pierre Halloix: suffixes are used to nominalise non-nouns. Above (chap. 12 §1), it has been seen that this is a major point for which scholasticism was chided by humanists. English and even more so German can emulate the Greek construction with their articles.[55] Without an article, Latin

52 Example from the section on nominalisation in Quirk et al. (1985: §17.51, p. 1289).

53 Both Latin translations are from Chevallier's edition, vol. 2, p. 573.

54 Nouns with possessive pronouns are automatically determined.

55 But the English article can nominalise much less than its Greek, French, or German counterparts: *le barbu* or *der Bärtige* has to be rendered as 'the bearded man' or, at least 'the bearded one', as the English article cannot be used with adjectives or infinitives, although it can be with -ing-forms (e.g. 'the making'). Latin could say *barbatus* to mean the same thing, but this participle may not be easily discerned as a noun in the sentence, and besides the reader cannot know whether the topic is a specific bearded man ('the') or some random one ('a'). Another possible solution to this problem, which Latin would not choose in this case, is using suffixes to make things clear (**barbator*); this is what the Slavonic languages tend to do in such circumstances, such as Russian бородатый ('bearded', adjective) vs бородач ('bearded man', *der Bärtige*, with nominalising suffix). Example from Birkenmaier (1979: 145).

was reluctant to use even the infinitive as a noun, as this tends to sound vulgar. Thus Petronius (*Satyricon* 52.3, ed. Ernout, p. 49) does this mockingly:[56]

> *meum enim intelligere nulla pecunia uendo.*
> 'I sell my understanding for no amount of money.'

Nonetheless, this function becomes much more common in scholasticism; for instance, in Thomas Aquinas, especially words such as *esse* or *velle* are often used as nouns. Incidentally, Aquinas also noted the absence of the nominalising article in comparison to Greek and the Romance languages (in *Expositio Peryermeneias* lib. 1, lectio 5, Leonina edition, vol 1, p. 26):

> *Set hoc uidetur habere instanciam in uerbis infinitiui modi, que interdum ponuntur ex parte subiecti, ut cum dicitur: 'ambulare est moueri'.*
> *Set dicendum est quod uerba infinitiui modi, quando in subiecto ponuntur, habent uim nominis; unde et in Greco et in uulgari Latina locutione suscipiunt additionem articulorum sicut et nomina.*
> 'But this seems to have force in verbs in the infinitive, which are sometimes used as subjects. For instance when one says "walking is moving".
> But it has to be said that verbs in the infinitive used as subjects have the force of nouns: thus, in Greek and Romance they have an article added to them like nouns.'

Now, it is obviously perfectly possible to do science in a language without articles, as Latin and Russian demonstrate, but this lack does bring limitations with it. This obstacle was never fully overcome in Latin; the solutions proposed over the centuries were all more or less emphatically rejected by stylists, who found them unacceptably ugly, although some of them would have worked well enough. We briefly summarise the three main ones.[57]

(i) The use of the Greek article as a loanword in Latin. This is occasionally done already in Antiquity, for example in Donatus' commentary on Terence:[58]

> *Tò istuc, exceptive dictum, [...].*
> 'The [word] *istuc*, said by means of stressing an exception, [...].'

This solution has the additional advantage that this article may be declined. Technical texts in early modern times, by authors who were not language purists, returned to this rather radical solution not infrequently. An example is the *Grammatica arabica* by Thomas Erpenius (Leidae, 1613, p. 6):

56 See Risch (1984: 27).
57 See Stotz (1996–2004: IX, §37.11 =vol. 4, p. 290).
58 From *Hecyra* line 608, ed. Marouzeau, vol. 3, p. 67; see *TLL* (s.v. *exceptivus*).

[...] nisi quod Mauri Kaf uno puncto superne insigniunt, hoc modo ڧ, τῷ Fe vero, ut ab illo differat, suum apicem subjiciunt, in hunc modum ڢ: qua quidem nota certe dignosces codices eorum ab iis, qui in Oriente exarati sunt.
'[...] except that the Moors mark the Qaf with only one upper point, viz. like this: ڧ; for the Fa, conversely, in order that it differ from it, they write its point below, like this: ڢ. By which sign you can distinguish their codices from those that were penned in the Orient.'

The *τῷ Fe* shows the reader that the Arabic letter-name 'Fa' is here taken as a dative which goes with *subicio*. Such a solution, however, can only pass as not too awkward in times when Greek is widely known among readers and highly esteemed (both being the case in early modern times). Another user of this article is the lexicographer Goclenius. In his lexicon, we frequently meet formulations such as *τὸ esse et τὸ operari*.[59] Even in the twentieth century, some Jesuits used this device. Karl Frank, for example, writes '*lex τοῦ fieri* (Satz des Geschehens)' (*Philosophia naturalis* 1.2.1.1, p. 50), apparently feeling that without the German equivalent the phrase might still be unclear. But this was considered a 'barbarism' by language purists.[60]

(ii) An indeclinable article *li* (also spelled *ly*) based on the French article was occasionally used by the twelfth-century translators and at scholastic universities.[61] Thomas Aquinas used *ly* 345 times in his three main works, which is not much considering that they contain nearly 3.5 million words. He uses it exclusively to single out words as we would do today using quotes, such as *ly pater* ('the word "father"').[62] The Pseudo-Bedan treatise *Sententiae philosophicae collectae ex Aristotele atque Cicerone* (PL 90) of unknown age (but hardly older than twelfth century) also makes use of this article very frequently. Petrus Cantor (d. 1192) uses it occasionally (in *Verbum abbreviatum* PL 205: 38 occurrences). This article was taken over as such from Old French, without inflection. Occasionally, it also appears as the more typically French *le*[63] or in an apparently southern Italian form *lu*.[64] In later times, it can also be used to cover more than one word, but

59 *Conciliator philosophiae*, p. 553, from 1609.
60 e.g. Krebs (1843: 90).
61 Stotz (1996–2004: IX, §37.12 =vol. 4, p. 290).
62 The instances can be viewed in Corpus Corporum by searching the Aquinas corpus for *ly*.
63 Moerbeke's translation of Aristotle's *Poetica*, ed. Minio Paluello, p. 44: *le facere*. See Tarán & Gutas's edition, pp. 137–139.
64 e.g. here and there in Iohannes Alexandrinus, *Commentaria in sextum librum Hippocratis Epidemiarum*, ed. Pritchet, pp. 138, 192, 408, 427, 434, sometimes in the text, sometimes in the apparatus. This text also and more often uses *hoc* as an article surrogate (see point (iii) below). Iohannes apparently flourished in the seventh century; thus, this Parisian article must be a later addition and should never stand in his main text; indeed, the best manuscript, E, usually does not have it. All known manuscripts are late (fourteenth to fifteenth century). They are predominantly

still in a function for which quotation marks would now be used, for instance in Federicus Chrysogonus (1472–1538), *Speculum astronomicum* 4.3:

> *Magnitudo enim est genus ad lineam et differentia est* <u>*ly*</u> *sine latitudine*.
> 'Magnitude is the *genus* for the line and <u>the</u> "without dimension" is the *differentia*.'

Thus, *ly* is not a full article but rather a marker of words like our quotes or Sanskrit's word *iti* (literally 'so') which has a similar function.

(iii) Another possibility for forging a full article in Latin is to use demonstratives such as *ille, ipse,*[65] *quod*, or *hoc*. We have seen above that this is the expected way for a language to acquire an article. The first of these led to the formation of almost all Romance articles among speakers of Vulgar Latin (Fr. *le*, It. *il*, Span. *el*, Port. *o*, Rom. *-ul*, etc.), the second to the Sardinian one *su*; we have met the third and fourth options above (chap. 21 §5 and at the beginning of the present §) but the phenomenon never made it into 'good' Latin, as it was clearly perceived as vulgar. Mediaeval folkloric texts such as the *Vita Amici et Amelii* do not have such scruples and often use it, sometimes also an indefinite article *quidam* (often preceding its noun: *quidam homo* = *un homme*) or *unus* in the same function. Descriptive texts about foreign parts, such as William of Rubruck's *Itinerarium*, a description of his journey to the Mongols in the thirteenth century, use this device to render indeclinable words declinable, for instance *Moal* ('Mongol'). In the book, there are nine instances of *ipse* in various cases followed by *Moal* and one with *ille*.[66] The same problem occurred with indeclinable biblical names. Lambertus de Monte (ca. 1500), for instance, wrote *ipsi Iaphet* to mark the dative case (*Quaestio de salvatione Aristotelis* concl., line 162, ed. Roelli, p. 152). The mathematician Carl Friedrich Gauß in the nineteenth century still sticks to *ipse* in order to render numbers declinable (e.g. *ipsius x* 'of the number *x*').[67] This rather inconspicuous article surrogate is quite often used in this function, but to my knowledge it is not used to nominalise non-nouns, such as **ipsum velle* for '*the wanting' (*das Wollen*, *le vouloir*).[68] The resulting 'articles' needed getting used to, but apparently

from southern Italy. Sicilian still uses today *lu*/*la* as definite article, although sometimes dropping the *l-*.

65 Stotz (1996–2004: IX, §37.2–10 =vol. 4, pp. 288–290).

66 An example: *quia vita* <u>*ipsorum Moal*</u> *et etiam tuinorum* (chap. 26). The *tuini* are the Buddhists he met at the Mongol court. The phrase *quia vita Moal et etiam tuinorum* could be ambiguous. An alternative would have been to decline *Moal* and write, for example, *Moalorum*.

67 Often used in *Disquisitiones arithmeticae*, e.g. §9, vol. 1, p. 11: *Sint f, g valores congrui ipsius x*.

68 Corpus Corporum searches of the kind *ipse*/*ille* followed by INF have not produced clear cases; with adjectives – such as *ipsum bonum* – the Platonic 'idea of the Good' is intended in Latin (like in Greek αὐτὸ τὸ ἀγαθόν).

Latin students did get used to these translations at the early universities (before the Renaissance). But in the long run, these pseudo-articles too were rather shunned by educated authors because they, too, seemed vulgar. Stylistically sensitive authors, therefore, had to live without an article.

Compounds and *nova verba*

§7 Quirk et al. (1985: §17.123, p. 1350) state that compounds and noun phrases are the most typical features of scientific English.[69] In contrast, the importance of newly formed features in Greek science seems to depend strongly on the science in question. In philosophical and theoretical scientific language, compounds have not been found to be very common (see chap. 21): a detailed study of those in Latin translations of book II of Aristotle's *Physica* revealed most of the compounds to be words formed with preverbs, which can easily be imitated by Latin.[70] True compounds – those containing at least two roots – are rare in the Greek text as well. But matters are different in other fields, such as botany or medicine, where many new *res* stand in need of names. In Greek these are often true compounds. In Latin they are often just taken over as loanwords by Latin translators.[71] Although Celsus, the first Latin medical writer whose work survives (see chap. 21), strives to say things in Latin, this is soon lost among his colleagues. Here is a quite typical example from Caelius Aurelianus (*Tardae passiones* I.115, ed. Drabkin, p. 448; fifth century):

> *Declinante passione cerotariis atque malagmatis simplicibus utendum, ut est diachylon.*
> 'When the disease diminishes, wax plasters and simple emolients [μάλαγμα] are to be used, such as diachylon [διὰ χυλῶν].'[72]

Greek words are very common; they may have sounded as 'professional' to patients as Latin-Greek ones do today. Often they are compounds. In theory, Latin, as an Indo-European language, should be able to form new compounds easily. But Latin compounds tended to sound odd to the educated Roman, according to Quintilian (*Institutio oratoria* I.5.70, ed. Rahn, vol. 1, p. 86):

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69 They offer an example sentence: 'At the mouth of the respiratory tube is *a series of velar tentacles, corresponding exactly in position to those of amphioxus, and serving to separate the mouth and oesophagus from the respiratory tube while the lampre is feeding*' (italics in original).

70 See Roelli (2014a) and the online list at http://mlat.uzh.ch/texts/compounds.html.

71 See Panagl (1986). On Greek words in Latin, see Biville (2002).

72 An unidentified medicine; Drabkin renders 'plaster of juices'.

> *Sed res tota magis Graecos decet, nobis minus succedit, nec id fieri natura puto, sed alienis favemus; ideoque cum κυρταύχενα mirati simus, incurvicervicum vix a risu defendimus.*
> 'But this matter [compounds] is more adequate in Greek; it occurs more rarely with us, but I do not believe that this is by nature. Instead, we prefer foreign things: thus we applaud [the compound] κυρταύχην [having a curved neck], but *incurvicervicus* can hardly be saved from ridicule.'

Quintilian provides examples of Latin compounds in the same chapter. In VIII.3 he addresses Latin's reluctance to form new words in general, be it by compounding, suffixation, or other means.[73] He rightly concludes that Latin should not shun such new words altogether (VIII.3.33, ed. Rahn, vol. 2, p. 162) as the purists would have it. Nonetheless, Latin authors tend to be very cautious when introducing new compounds; for example, Aulus Gellius tries *inlatabile* (*Noctes Atticae* I.20.9, ed. Marache, vol. 1, p. 64) for Euclid's (μῆκος) ἀπλατές ('without breadth'), which defines a line in geometry, introduced with a cautious *quod exprimere uno Latino verbo non queas, nisi audeas dicere inlatabile* ('which you cannot express in Latin in a single word, unless you dare to say *inlatabile*'). Indeed, the word *inlatabile* never seems to have been used again.[74] Often new words were made to sound less harsh by adding *ut ita dicam*, *si licet dicere*, or similar to gain the reader's benevolence.[75] For instance, Seneca invents in his *Naturales quaestiones* (III.23, ed. Oltramare, vol. 1, p. 140) the harmless-looking word *supernatare* (*ut ita dicam supernatantes*) to describe water that wells up or literally swims on top of the Earth. In Greek such a new compound (as ὑπερνέω) would have been totally inconspicuous. Latin poets were somewhat freer to create new words; for example, Statius (*Silvae* III.2, line 47, ed. Frère, p. 107) uses *supernatare* without apology. Nonetheless, even in poetry a rather limited number of types of compounds is common: especially those in *-fer, -ger, -ficus, -cola*.[76] Late Antiquity and the Middle Ages will also use neologisms more freely, especially in medicine and scholasticism. PL has, for instance, 132 instances of *supernatare*.[77]

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73 *Institutio oratoria* VIII.3.30, ed. Rahn, vol. 2, p. 162: *Fingere, ut primo libro dixi, Graecis magis concessum est, qui sonis etiam quibusdam et adfectibus non dubitaverunt nomina aptare, non alia libertate quam qua illi primi homines rebus appellationes dederunt (*'The coining of words, as I stated in the first book, is more permissible to the Greeks, for the Greeks did not hesitate to accommodate words to certain sounds and emotions, using the same liberty by which the first human beings gave names to things').

74 Only this one hit in Corpus Corporum. Lindner (2002: 161) argues that Latin was in fact quite 'kompositionsfreudig', despite Latin authors' claims to the contrary. For authors aware of Latin style, this is certainly not the case.

75 See Hélin 1960 about these 'apologies'.

76 See the data in Lindner (2002).

But even in the Middle Ages, true compounds are only rarely coined. Most of the time, new words are formed using prefixes, or even more often suffixes (see §8). A safer option for Latin writers has to a greater or lesser extent always been to introduce Greek words into their texts as loanwords. This is what the humanists would rather do, but it is also very common in medical writers such as Caelius Aurelianus, as we have seen. Some mediaeval authors who had access to Greek scientific or scholarly prose tried to use more Latin compounding, such as John Scotus Eriugena (see chap. 9 §11) or Liutprand of Cremona (ca. 920–972),[78] but they had little success. The discussion of the extent to which writers may forge new words continued throughout Latin's lifespan, but the consensus remained rather on the cautious side.

Today, the language of science that is most fond of using compounds is certainly German. It can even produce compounds consisting of exclusively Graeco-Latin constituents, such as *kommunikationssysteminterne Konstrukte* (*communicatio* + σύστημα + *internus* + *constructio*),[79] or mixed ones with German or English constituents (the latter being especially en vogue these days, although disliked by conservatives), for instance *hybrider Imitationscluster*.[80] It would seem that compounds are very useful in scientific language, but their use can be overdone and they can be used to produce utterances with little palpable meaning, something that some German writers were and are very good at. In English, compounding is also more common than in Latin, though compounds are less conspicuous as they are usually not written as one word; they tend to be treated as a type of noun phrase.[81]

Suffixation

§8 The lack of an article and reluctance to compound can be compensated by subordinate clauses (especially relative ones). But they can easily become too much to handle for the reader. To a certain extent, they can also be alleviated by suffixation.[82] Above (chap. 18 §2), we have seen that suffixes become significantly more common in the Middle Ages. Some of the authors in the general scientific corpus,

77 This observation may also be explained in terms of Stotz's *Normenentfaltung*: once someone like Seneca made the first step, later writers lost their restraint regarding a word.

78 On his Greek, see Koder (1980). It seems to have been more spoken than literary Greek.

79 From Luhmann (1990: 24).

80 Oral utterance at a conference I attended. I am not sure this utterance made any sense at all.

81 e.g. Quirk et al. (1985: §17.104–108, pp. 1330–1334). Compare English 'garden fence' to German *Gartenzaun*.

82 For more details on some of the suffixes in Thomas Aquinas, see Roelli (2013).

especially scholastic ones, use them much more frequently than average. This is especially true for adjective suffixes, but also for some noun suffixes, *-tio* being the most conspicuous case. Despite large standard deviations between authors, the following suffixes can be safely said to be more common in the Middle Ages than in Antiquity (see table 9 above): *-alis*, *-bilis, -inus; -itia, -ntia, -tas, -tio*. Suffixation is rightly seen as typical for scholastic Latin. In Roelli (2013), I searched entries in the Schütz lexicon for Thomas Aquinas that never occur in classical or early mediaeval Latin[83] or PL. Excluding Greek words and regularly formed adverbs from attested adjectives, the following 115 words remained (the suffixes studied in chap. 18 are underlined):

> *actuare, agibilis, amativus, appetibilitas, argumentativus, assumptibilis, campsorius, causalitas, certitudinalis, cognoscibilitas, cognoscitivus, cointelligere, communicabilitas, concausa, condicionalis, condicionatus, condignativus, condignitas, condividere, connaturalitas, consiliabilis, consiliativus, conspecialis, constrictivus, contiguatio, contrapassio, contrapassum, contumeliatio, contumeliativus, deratiocinari, deteriorativus, difformiter, dimensivus, dinotica, discontinuare, discontinuatio, discontinuus, disputativus, divinativus, doctrinatio, executivus, exemplaritas, exercitivus, exigitivus, fontalitas, formalitas, gubernativus, habilitatio, ideare, ideatio, immediatio, immutativus, impotentialitas, improbabilitas, improcessibilis, incommunicabilitas, incompossibilis, incorporeitas, indisciplinabilis, individuare, individuatio, infiguratio, iniustificatio, inquisitive, intimativus, inventivus, iudicativus, iudicatorium, laesivus, latitatio, legispositivus, limpiditas, materialitas, meliorativus, nutrimentalis, oboedientialis, occasionare, opinativus, originare, partialitas, parvificentia, parvificus, parvipensio, pervietas, postpraedicamentum, potentialitas, praeacceptio, praeconsiliatus, praedeterminatio, praevolatio, principativus, protestativus, quidditativus, regitivus, reminiscitivus, retributivus, satisfactivus, situalis, speculabilis, sperativus, subactivus, subalternare, subauctoritas, substantificator, substantivare, supersubstantialitas, tactivus, totalus, transcorporatio, unibilitas, unitive, univocare, velleitas, volibilis, voluntabilis.*

Practically all non-verbs in this list are formed with some of the mentioned suffixes; prefixes are also very common. This practice is, indeed, one of the most typical features of scholastic Latin. It was strongly rebuked by humanists who wanted to return to 'pure' Latinity. They especially chided scholastic suffix constructions such as *entitas* or *perseitas*, as we have seen Valla do (chap. 12 §1). Despite their criticism, suffixation worked well to translate, for instance, an otherwise untranslatable τὸ καθ' αὑτό clearly and succinctly with *perseitas*.

83 The dictionaries by Georges and Niermeyer were used to exclude such words.

Latin language engineering

§9 Certainly, by language engineering Latin could have been adapted to Greek or other source languages much more strongly than what finally prevailed as scholastic and later academic Latin. The mystical author Marguerite Porete (d. 1310) can provide a glimpse what such a 'Latin' could have looked like also in the sciences. In this case, the source language is Old French, but a wish to emulate scholastic Latin can clearly be felt; in fact, the Latin text was translated from a French original (CCCM 69, pp. 400–403):[84]

> *Modo est in esse sui primordialis esse, quod est suum esse. Et dimisit tria et fecit de duobus unum. Quando est illud unum? Illud unum est quando anima est resoluta in illam simplicem diuinitatem, quae est unum simplex esse expansae et dilatatae fruitionis in plano scire absque sentimento supra mentem. Illud simplex esse facit in anima ex caritate quicquid anima facit, quia uelle est simplex effectum.*
> 'Now, in its [the soul's] being the primordial being is encountered, which is its true being. And it has left behind the three and made one out of two.[85] When does this "one" happen? This oneness happens when the soul is resolved in that simple divinity that is simple oneness of pervasive and spread-out fruition in full consciousness, devoid of feeling, above thinking. By charity, this simple being makes the soul do whatever the soul does, as [in this state of mind] volition happens automatically.'

This language uses *ille* as a normal article (e.g. *illud unum*) and infinitives are often nominalised (*illud simplex esse*). This kind of Latin was, however, rejected by educated authors for being 'vulgar'. Latin did change at the scholastic universities, but not in such an extreme way. Scholastic Latin was a very successful form of Latin, but the humanists derided it and, concerning the features discussed in this chapter, were able to make scholars and scientists more cautious not to strain too far from 'Classical' Latin.

Latin thus had to go different ways, and one might wonder whether the different character of later Latin scientific language, compared to Greek, evolved to overcome these problems. Groups of terms could not so easily be turned into 'entities' using the article; instead, suffixation, logic, then mathematisation follow in Latin science, as is still the case in English-language science today. Easy compounding can also be seen as a negative point for scientific clarity, as we have seen for German examples: like the *ablativus absolutus*, Indo-European com-

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84 The corresponding French text: 'Or est ceste Ame en l'estre de ce premier estre qui est son estre, et si a laissé trois, et a fait de deux ung. Mais quant est cest ung? Cest ung est, quant l'Ame est remise en celle simple Deité, qui est ung simple Estre d'espandue fruiction, en plain savoir, sans sentement, dessus la pensee. Ce simple Estre fait par charité en l'Ame quanque l'Ame fait, car le vouloir est simple devenu.'

85 The three are soul, world, God; the two are soul and God.

pounds are underdetermined, as the possible relations between their constituents can be manifold. A Latin writer would more clearly but less succinctly speak of something like *constructiones in systemate communicationis inhaerentes* (ignoring semantic changes in the constituent parts) for what Luhmann put into two German words in the example above. Thus, a Latin writer has to declare the syntactic relations more explicitly than a German one. Latin's different and, compared to Greek, less versatile structure clearly produced something new, a scientific Latin, which, for instance, led to texts like Newton's with our present understanding of classical physics, where for example 'energy' has become a very different thing from Aristotle's ἐνέργεια. It is questionable whether Greek science would have led to science comparable to what we have today. Ultimately, it is the scholastic style that has prevailed in modern scientific writing: precision, not beauty; small vocabulary; and simple syntax are now all hallmarks of scientific English, at least in the natural sciences. A random modern example of the latter shows clear similarities (Doudna & Charpentier 2014):

> We review the history of CRISPR (clustered regularly interspaced palindromic repeat) biology from its initial discovery through the elucidation of the CRISPR-Cas9 enzyme mechanism, which has set the stage for remarkable developments using this technology to modify, regulate, or mark genomic loci in a wide variety of cells and organisms from all three domains of life. These results highlight a new era in which genomic manipulation is no longer a bottleneck to experiments, paving the way toward fundamental discoveries in biology, with applications in all branches of biotechnology, as well as strategies for human therapeutics.

Relative clauses and noun phrases are very frequent, as are -ing-forms. The technical terminology relies on the one hand on Graeco-Latin terms ('interspaced', 'palindromic', 'biotechnology', etc.), on the other on acronyms ('CRISPR', 'Cas9'). The standard formulations and the logical structure would be typical for a scholastic text as well. One might speak of a modern scientific koine with Greek roots and a scholastic trunk that is still thriving in modern English science.

These somewhat different approaches to scientific language in Greek (and similarly German) and in Latin (and similarly English) may have played their part in the development of, say, Anglo-Saxon analytical philosophy vs the classical German philosophers, or maybe even of typically English natural vs typically German human sciences. It would seem that Greek was good at both; it produced both a Euclid and an Aristotle.

Science as a Graeco-Latin *Denkstil*

§10 With all of this, it becomes clear that one can speak of a Greek scientific *Denkstil* that developed uniquely in classical and Hellenistic Greek times, and was then transformed into somewhat different but related *Denkstile* in Latin from scholasticism to the Scientific Revolution, from which our modern science descends organically. It would seem that both speculation (corresponding to criterion II, 'explanation') and technology (implicit in criterion III, 'testability') on their own are universals in highly organised cultures. Indeed, technology has tended to advance quite linearly in many parts of the world;[86] individuals making up fanciful theories of everything abound in at least China and India besides ancient Greece, as we have seen. The Greek *novum* was to link these two things and use them like two legs to walk by moving them alternately (in Galen's simile): attempting to render discoveries and technological advances understandable or, conversely, attempting to make fancy theories systematically testable and also rejectable. The Greeks, and especially Aristotle and his school, sought step-by-step, formalised new approaches to understanding things based on observation and logical, formalised thought, and not on tradition or hearsay. And they founded schools of thought in many fields. This seems to have been the only independent time this happened in human history.[87] It may not be an exaggeration to call science a Greek *Denkstil*. Whether this alone should warrant the name 'science' is, of course, a matter of definition, but this distinctive intellectual current from ἐπιστήμη through (*ʿilm* and) *scientia* to *Wissenschaft* and 'science' certainly warrants its own distinctive name, although each of these changes of linguistic medium also brought along some changes to the originally Greek *Denkstil*.

86 See e.g. Hägermann & Schneider (1991) for 750 BC to AD 1000.
87 Störig (1965: 51) reached the same conclusion.

Summary and concluding remarks

§1 This book has explored several paths toward studying the relation between science and language, especially the Latin language – the leading language of science and learning for the longest time. Scientific Latin is the far too little-studied connecting element between Greek science in Antiquity and contemporary modern science in what could be called a *translatio linguae* (chap. 16 §3). Latin had to face problems in vocabulary, syntax, and style in order to express and appropriate Greek scientific thought. Although a radical dependence of thought on language as advocated by Whorf and others certainly goes too far – after all, human beings do share a body with a more or less identical *sensorium* grounding our experience in the world – the more remote from direct sensation ('abstract') things get, the more room for differences among peoples and languages emerges. As most scientific languages in the history of mankind have been in contact with one another and have influenced each other decidedly (as has been described for Latin from Greek, then the European vernaculars from Latin), it is not trivial to ascertain how far divergence in scientific expression is feasible. In this book, it has become apparent several times that Greek, Latin, German, and English have produced somewhat different 'flavours' of science. Our modern European scientific languages strongly depend on Latin; indeed, they are full of Latin loanwords and calques, especially so in the case of English, in which language 57 % of the vocabulary in one sample ultimately derived from Latin, either directly (28.24 %) or through French (28.30 %).[1] For instance, English very often uses Latin to derive adjectives from Germanic nouns: 'star' → 'stellar', 'heart' → 'cardiac', and so on.[2] Such strata from prestigious languages of learning for cultivated concepts are frequent in many cultural spheres: Hindi or Thai tend to use Sanskrit words similarly to how English uses Latin ones. The strong influence of Latin on modern scientific English will have become palpable throughout this study. What follows summarises the main results of the book.

§2 Part 1 developed the following matters by working back from the present; here they are summarised chronologically. The semantics of 'science' were studied, as well as the question of whether premodern times had similar concepts and how different languages have called and still call such activities. The concept 'science'

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1 According to the computerised survey of about 80,000 words in the *Shorter Oxford Dictionary* (3rd ed.) by Finkenstaedt & Wolff (1973).

2 On this topic, see the interesting article https://en.wikipedia.org/wiki/Latin_influence_in_English (December 2018), providing many examples. In similar circumstances, German uses compounds instead: 'stellar nebula' = *Sternnebel*, 'cardiac attack' = *Herzinfarkt*.

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turned out to differ somewhat between languages and through time since Classical Greek, which is hardly surprising: the same is true for most abstract notions (think of 'art', 'religion', 'nation', or 'family'). Nonetheless, this study has hopefully shown convincingly that science goes back organically to scientific activities undertaken in Greek Antiquity, which in turn owe their existence to a unique combination of several factors in classical Greece, most importantly: natural-philosophical speculation, the sophist movement analysing language, and Aristotle and his school. Although many similar factors can be observed in cultures before and alongside the Greeks, their combination into a durable way of thinking (Fleck's *Denkstil*) recognisably similar to our 'science' emerges only with the Greeks in the time around 500 BC (chap. 7 §9). These factors led to a demand for stronger requirements to make explanations credible and certain, such as mathematical proof, precise observation, but also a scrutiny of (the Greek) language and its precise form of assertions and of logic (chap. 7).

Although many sciences were begun in classical and Hellenistic Greece, Classical Greek did not at first have a single word to denominate 'science' as a whole. Plato and Aristotle mostly used ἐπιστήμη for the firmest kind of knowledge available to man (in the plural already denoting scientific disciplines for Aristotle), although for mathematical sciences μάθημα was also used. The prime activity reaching it was φιλοσοφία, but the higher τέχναι, such as medicine, or ἱστορία also strove for maximal attainable certainty. In Hellenistic and Roman times, the word ἐπιστήμη seems to largely coincide with our 'science'; in Latin, the words *scientia* and *disciplina*, and in some contexts *ars* (especially as *artes liberales*), were its usual renderings. Which one was chosen depended largely on the author. Only in the High Middle Ages did the first option become the standard term (helped by the Arabic *ʿilm*), whereas the second developed more and more toward our 'discipline' as a single scientific branch or, in fact, a branch of other activities as well. It was shown (1.3) that for most pertinent words in Greek, Latin chose a single equivalent, a kind of *interpretatio Romana* of Greek epistemology.

Historians of science have proposed vastly different definitions or characterisations of what science is. Many of their criteria were found not to be applicable to diachronic samples of science. Some were reviewed, and a few were found that characterise science in a similar way to the following criteria. In order to be able to tell science apart from other activities through this entire time span, a list of criteria was proposed that scientific study needs to fulfil. The first three items were treated as necessary, the second three as additional characteristics that may be missing in some cases: (I) a systematic method and well-defined topic, (II) finding patterns and explaining them step-by-step, (III) an unbiased seeking of confirmation or refutation, (IV) coherence and non-sterility, (V) a community effort, and (VI) formalisation of the results.

These points together lend themselves to a specific, ‘scientific’ *Denkstil*. Points (II) and (III) together provide the typical combination of a general and theoretical explanatory framework and the gathering of trustworthy data to check and rein it in. Among such approaches, science must take into account what may be called ‘generally acknowledged facts’ (alluded to in points II and III). Science using criteria II and III to progress further (using these ‘legs’ to walk, as Galen put it) will produce new such generally acknowledged facts, thus accelerating its own development. Since these are fallible (like everything human), a revolutionary component joins the evolutionary one, occasionally leading to breaks in scientific development. Within these rather general characteristics, many different sub-*Denkstile* are possible, and the sciences have, indeed, a tendency to continuously evolve their *Denkstil*; Fleck clearly showed that this does not entail a linear progress toward ‘truth’, but it also seems clear that the more generally acknowledged facts there are, the less freedom for *Denkstile* within a science.

Point VI, ‘formalisation’, is conducive to a special kind of language, for which the following criteria were tentatively put forward: (i) well-defined terminology, (ii) exactness and unambiguity, (iii) extendability and flexibility, (iv) perspicuity, and (v) evidentiality and modality. Together, they constitute requirements for a certain kind of technical language. It seems clear that the more a science advances, the more technical its language will become, as it has to cover more and more ground and gets further and further from the everyday matters for which everyday language is tailored. If there is a more or less autonomous and sizeable community of researchers (point V), they will automatically develop their own technical jargon.

The above criteria have not restricted scientific study to ‘nature’. Indeed, it was found that this restriction is a recent acquisition of the English language that is not shared by most other European languages used for comparison (chap. 1). Thus, today, philology, linguistics, sociology, historiography, law, and other fields that were traditionally seen as scientific are usually no longer called ‘sciences’ in English. The term now most often used for them is ‘scholarship’. This significant and unilateral change in English, which was shown to become clearly noticeable only toward the end of the nineteenth century, was not followed in the present study, and ‘science’ was treated in its original wider meaning covering fields of activities delineated by the above criteria. It was pointed out that this tendency of the English language might be linked to the Royal Society’s exclusion of human sciences and theology from its studies in the late seventeenth century in order not to get caught up in Reformation quarrels (chap. 14 §3). Due to this special development of English, contemporary English-language histories of science have a tendency to be histories of natural science and to produce a skewed view of all the activities that were seen as scientific in their time and as belonging together as such.

§3 Part 2 provided a panorama based on Latin primary texts in order to illustrate the historical development and exemplify the language and *Denkstil* used among Latin scientific authors. The first chapter pointed out that the language of science depends on the scientific genre used. It was noted that some forms of scientific communication important in Greek and Latin times, such as didactic poetry, dialogues on science, or letters between scientists, have fallen quite out of use in more recent times. A further difference is whether texts were written by specialists for specialists, with didactic purposes for future scientists, or for a wider public. It has been stressed that in order to compare scientific language, if possible, care should be taken to make comparisons within the same textual genre. After these preliminaries, a chronological discussions began with a brief look at Latin's rôle model, Greek (chap. 7). Then, epochs of Latin science were proposed and important authors and texts briefly presented. It became clear that the usual epochs (Antiquity, Middle Ages, modernity) do not work well for science. Instead, the following divisions were proposed and described; they alternate between a relative stability of scientific approach and times of revolutionary change. The foundations of Roman science were laid by imports from Greek roughly from 100 BC to AD 200 and by the growth of the genuinely Roman science of jurisprudence (chap. 8), followed by an approach mostly followed by Christians which was centred on encyclopaedism and soon acquired the Platonic classification of the sciences into the *artes liberales* (chap. 9)*;* it lasted from Late Antiquity through the Early Middle Ages, and was of a decidedly didactic and conservative nature. Significant novelty in many fields, as well as new impulses from newly available Greek and Arabic texts, marked an important caesura in the long twelfth century (chap. 10). The Greek scientific *Denkstil* only fully arrived in Latin in this period – the turning point of Western European intellectual history. A variety of approaches were developed by different people, some of which led (chap. 11) to scholastic university science with a very distinctive and standardised kind of Latin which developed at the new universities with their emphasis on disputation, dialectic, and logic. Early modern times (chap. 12) brought new approaches again, but most of them, especially the humanist and the hermetic ones, were rather dead ends for science, and the Renaissance can be seen rather as a time of stagnation or even regress in scientific methodology with its often rigourist, classicist approach to Latin. But 'scholastic' science kept being widely practised through the Renaissance at many universities and was enriched by more experimental *magia naturalis*. The Scientific Revolution (chap. 13) brought more important and lasting changes to scientific methodology in the later sixteenth and seventeenth centuries which quite justify the label. Again, a variety of new methods were proposed and used with different degrees of success in various fields. The most successful novelty was certainly a stronger use of mathematics (which over the past few centuries had started to produce the necessary foundations) and of a methodical use of experimentation. This led to a kind of science that started to actively 'mine' new generally acknowledged facts, enabling it to accelerate its development considerably. Latin was still the dominant language of science throughout the Scientific Revolution, a Latin much closer to 'useful' scholastic Latin than to 'beautiful' humanist Latin. The international aspect the movement had thanks to Latin helped it gain a momentum that would hardly have been possible had everyone already used their own vernaculars. Chapters 14 and 15 studied Latin's demise and scientific niches where Latin kept being used beyond the eighteenth century respectively. The main culprit of Latin's demise was found to have been French nationalism. The most enduring niche of scientific Latin can be found in Jesuit schoolbooks of the first half of the twentieth century. Some consequences of the change of linguistic medium from Latin to vernacular science concluded this part of the book (chap. 16).

§4 Part 3 studied scientific Latin linguistically from several angles, mostly numerically or comparatively. Corpus Corporum, an open meta-corpus of Latin texts developed for this study, was used in most cases. After an introduction detailing what is known about scientific English (chap. 17), the first three chapters (chaps 18–20) used corpus linguistic methods to study scientific Latin, especially the differences in its PoS composition and syntax. Five large benchmark corpora for different periods made up of prose texts of all kinds were used as a basis for comparison. They were compared with a general group of forty more theoretical scientific prose texts (chap. 18), then with four more thematic scientific samples: an arithmetic sample was studied in some depth, as were samples of historiography, of scientific poetry (chap. 20), and of medical texts, representing less strict or less theoretical science (chap. 21). Some further out-groups were compared to the general sample: poetry, the Vulgate, the *Digesta*, a collection of mediaeval charters, and some scientific translations from Greek. The corpus linguistic findings are summarised in chapter 20 §8. Some parameters known to be specific to scientific English – the use of non-conjugated verb forms, prepositions and conjunctions, the passive voice, a lack of the first person singular, and nominalisation of processes – were tested for Latin as far as they were applicable. Some of them were found to be also typical for scientific Latin (high numbers of PREP, 3rd PAS; low numbers of 1st SG, POSS), but others were not (CONJ, non-finite verb forms); moreover, some seem to be typical for scientific Latin but not for scientific English, such as high numbers of ADJ. Some are typical for Latin science but not directly comparable to or not yet studied for English (high numbers of NOM case, the verb ESSE, suffixation; low numbers of *ablativus absolutus*), some seemed typically Greek (sentence particles), and some opened up new questions: low entropy (hitherto not studied for scientific texts). Principal component analysis and stylometry were employed to plot the texts in two-dimensional space and in tree form respectively, based on parts of speech and similar parameters. It proved possible to identify quite clear-cut groups of types of Latin; they were compared to those observed in part 2. The results are summarised in chapter 19; they were labelled as (i) hexametric, (ii) rhetorical, (iii) plain, (iv) bombastic, (v) scholastic, (vi) mathematical, and (vii) modern academic Latin. It became clear that due to Latin's deep memory, these approaches and their respective styles of writing did not supplant one another for good: for instance, Vesalius could still use a rather rhetorical approach in early modern times. Nonetheless, it seemed that after the great watershed of the long twelfth century, only the last three approaches would be used for serious scientific communication among experts in the more theoretical sciences (which one of them, depended on the field). Whereas the rhetoric approach in science can be traced back to Plato, the scholastic one to Aristotle, and the mathematical one to Euclid, the final 'modern academic' style looks like a summa of the earlier styles and lacks a clear Greek model – a Latin that would have been very well suited as an international scientific auxiliary. For political reasons this did not happen. Before the long twelfth century, Latin science was nearly exclusively popular science or practical science. It was shown that the language of an example of the latter, medicine, was quite similar to the 'plain' approach of Pliny (chap. 21), also and even especially after the Middle Ages. Scholastic and mathematical texts clustered furthest away from the non-scientific benchmark samples together with translations from Greek. Poetry and the Vulgate were also far off, but in opposite directions. For the arithmetic texts (chap. 20), groups within the sample were less clear-cut, but the sample as a whole differed strongly from normal Latin; mathematically minded authors from the general science sample (Copernicus, Newton) clustered closest to it. It seems that the language of these texts remained rather constant and closely linked to that of Euclid (the first verbatim Latin translation of him ended up close to the root of all subsequent arithmetic texts). The texts from the eighteenth century and later tended to cluster somewhat apart. The language of historiography was found to differ quite strongly from the more strictly scientific texts, but not to differ much from non-scientific Latin; that of scientific poetry was, as expected, found to share some characteristics with other poetry and some with prose science.

Different approaches were chosen for the remaining chapters. Chapter 21 studied how new phenomena were named by Latin medical writers in different times. It found a great dependence on Greek and, from early modern times onward, formalised systems of, for instance, different Latin suffixes for different kinds of ailments. In the mathematical sciences, formalisation went even further, a step that can hardly be underestimated in its importance for the development of modern much more formalised forms of science that are thus much less dependent on natural language – a development that within 'richer' Greek might not have seemed necessary. The abundance (or dearth) of a language's linguistic tools may thus be secondary to the desire within a community of speakers of a language to express certain kinds of thought. If such a desire is present and there is time, it will find its ways of expressing itself. This is very well illustrated by the fact that even minor languages have in the past two centuries acquired the means to discuss scientific topics of nearly any kind – notwithstanding that this happened and still happens largely by borrowing structures from the major scientific languages of Latin, French, German, and English. Indeed, English and German have borrowed so much of their structure and vocabulary from Latin that not only will French and the Romance languages have to be called Latin's daughters, but the Germanic languages can very fittingly be called its stepdaughters.[3] Above (chap. 16 §2), it was stressed how much vocabulary and even syntax was taken over from Latin to form Germanic standard languages that could be used in all contexts, including the scientific. The next two chapters, consequently, compared how Graeco-Latin scientific terminology was adopted by other languages: by traditional ones (chap. 22) and by contemporary ones (chap. 23). Different approaches have become clear: Sanskrit packed much information into compounds, Chinese invented new combined characters in its flexible writing system, and Arabic often used circumlocutions. Among the European languages, some have just taken over Latin terms (the Romance languages, English), some have made calques (Icelandic), some sometimes the former and sometimes the latter (German, Russian), some have only borrowed Greek-based terms and adapted Latin-based terms (Modern Greek), and some have used loanwords (Indonesian).

Chapter 24 sought to synthesise the relationship between science, culture, and language. It was argued that science, as defined in chapter 4, is a Greek *Denkstil* that can be found at best *in nuce* outside the Greek cultural horizon. Mesopotamian and ancient Egyptian candidates for science, as well as some from India and China before intense Greek contact, were briefly compared. Then the typical language used in scientific Greek and its translation into Latin was tackled. The three potentially most important linguistic features for scientific Greek expression were considered: nominalisation using the article, free compounding (both hard to translate into Latin), and new terms made by suffixation (typical for scholastic Latin). Nonetheless, and not withstanding that it took Latin a long time until science started to be done seriously in this medium, in the Late Middle Ages and

3 As Leonhardt (2013: 37) proposed.

early modern period Latin fulfilled the rôle of *lingua scientiarum* very well indeed. In order to do so, it made use of various devices, such as creating new Latin terms by suffixation or the formalisation of thought in many fields, especially mathematics, logic, and scholasticism, thus taking over, but slightly adapting, the Greek scientific *Denkstil*.

§5 By virtue of being the linguistic medium of the Scientific Revolution, and through the widespread adoption of its scientific vocabulary, Latin can be said to lie directly at the roots of modern science (whereas Greek does so more indirectly), and in fact in a sense it lives on in modern scientific languages (chap. 23), especially in English. Not only does English take very much of its scientific vocabulary from Latin (both directly, and indirectly through French) but it follows many of its structures, such as -ing-form clauses in the function of the Latin *participium coniunctum* and *ablativus absolutus* (chap. 16 §2). This can be seen as standing in a certain contrast to German, which was in many fields the leading language of scientific communication from the middle of the nineteenth century until Germany's defeat in the two World Wars. German functions much more like Greek; in many fields, full advantage was taken of its ease of compounding words and deploying complex syntactic structures, which may be best seen in its philosophers and human scientists, whose texts are often nearly untranslatable into English. Such compounds are often *Augenblicksbildungen,*[4] something strongly disliked by Latin and English. In Latin this tendency was weakened by scholasticism, which lost much of Latin's inhibitions in coining new words, but humanism tried to check this development, in some sciences with more success, in others less. Contemporary English science can be seen as driving this isolating approach even further: formulas and Graeco-Latin technical terminology that is often subsequently used only as acronyms abound today; *Augenblicksbildungen* are not used. This study has thus, in passing, demonstrated differences in the scientifico-linguistic approach in different languages, especially in Greek, Latin, English, and German, and revealed a certain congeniality of Greek and German on the one hand and Latin and English on the other. Clearly, this is a field that would need a lot more research and that does, finally, seem to be attracting more attention. The hegemony of English as the vehicle of science may be seen as a kind of revival of the Latin way of formulating science in language, although with the use of for-

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4 We have met many such cases that were hard to translate into English in the passages quoted in this book: *Erkenntnisarbeit*, *Methodenzwang*, *Normenentfaltung*, *voraussetzungsloses Beobachten*, or *sachliches Wissenwollen*. Such compounds may continue to be used in their fields or they may not; in either case, their first use is seen as something natural in German scientific language with no need of justification or even definition.

mulas and less dependence on linguistic structures, Anglo-Saxon science has become more technical and less philosophical, one might say. The general scientific *Denkstil*, however, seems to have been largely preserved in the transition from Latin to the European vernaculars and especially to English today. The English of many contemporary natural sciences has reached a degree of 'ugliness' – rhetorically speaking – that the 'worst' scholastic Latin writer could hardly have managed in Latin, which may show that the scholastics were on the right track in putting content before beauty in science. In conclusion, the fixed language Latin can therefore be said to be not at all dead, but thriving and in full vigour in scientific English today.

Appendix 1

See chapter 18 §3 above. These are words not present in the Perseus collection of texts older than AD 200, excluding Tertullian, who is in fact the first attested user of many of them.[1] The list illustrates the kind of growth scientific Latin has produced since AD 200. Proper names and names of classes of beings are not included, and nor are their derivations (*rabbinus, isiacus*), except those that seem to have become part of the language (*apostolus, daemonicus, satanicus*). The table in chapter 18 §4 provides information on the authors and texts. The last 5,000 words of each work were used to produce this sample of post-classical coinings. The list is lemmatised and contains for each lemma its PoS and the number of occurrences in the sample.

<u>Tertullian</u>: 1 *abyssus* (ADJ), 1 *adulatrix* (N), 1 *aedificatorius* (ADJ), 1 *affirmator* (N), 2 *angelus* (N), 1 *angelicus* (ADJ), 1 *antichristus* (N), 1 *apoplexis* (N), 1 *apostata* (N), 3 *apostolus* (N), 1 *apostolicus* (ADJ), 1 *archangelus* (N), 1 *auctrix* (N), 1 *auersatrix* (N), 1 *baptisma* (N), 1 *baptizator* (N), 2 *biaeothanatus* (N), 1 *calumniosus* (ADJ), 1 *capillago* (V), 1 *cauositas* (N), 1 *coemeterium* (N), 1 *commartyr* (N), 1 *condicionalis* (ADJ), 1 *conresupinatus* (ADJ), 1 *contrectabilis* (ADJ), 1 *corruptrix* (N), 1 *daemonium* (N), 2 *daemonicus* (ADJ), 1 *demulco* (V), 1 *dormitio* (N), 3 *ecstasis* (N), 4 *ethnicus* (ADJ), 2 *euangelium* (N), 1 *euocator* (N), 1 *exhibitio* (N), 1 *exorbitatio* (N), 1 *exsucus* (ADJ), 1 *frustratorius* (ADJ), 2 *haereticus* (ADJ), 1 *humiliatio* (N), 1 *idololatria* (N), 1 *immunditia* (N), 1 *impuritas* (N), 1 *incolatus* (ADJ), 1 *incorruptibilis* (ADJ), 1 *incubator* (N), 4 *indiuisibilis* (ADJ), 1 *infaeco* (V), 1 *interstruo* (V), 1 *inuitatorius* (ADJ), 3 *martyr* (N), 1 *martyrium* (N), 1 *mundialis* (ADJ), 1 *natiuitas* (N), 1 *operatrix* (N), 2 *paracletus* (ADJ), 2 *patriarcha* (N), 1 *perculsus* (ADJ), 2 *phantasma* (N), 1 *postremitas* (N), 1 *praedicatrix* (N), 1 *praelibatio* (N), 1 *praenuntiatio* (N), 1 *presbyter* (N), 1 *profunditas* (N), 2 *propheta* (N), 1 *propheto* (V), 1 *propheticus* (ADJ), 1 *pseudopropheta* (N), 1 *refrigerium* (N), 2 *reliquatio* (N), 1 *renidentia* (N), 1 *renuntiator* (N), 1 *rescissio* (V), 8 *resurrectio* (N), 1 *reuelatio* (N), 1 *sepultor* (N), 1 *somniator* (N), 1 *specular* (N), 1 *succussus* (ADJ), 1 *transactio* (N)

<u>Victorinus</u>: 1 *descriptiuus* (ADJ), 106 *diffinitio* (N), 1 *numerositas* (N), 2 *praemagnus* (ADJ), 24 *substantialis* (ADJ)

<u>Augustine</u>: 5 *angelus* (N), 2 *apocalypsis* (N), 2 *apostolicus* (ADJ), 6 *apostolus* (N), 1 *azymus* (N), 1 *canonicus* (ADJ), 7 *carnalis* (ADJ), 3 *carneus* (ADJ), 1 *contextio* (N), 1 *creatura* (N), 1 *dilectio* (N), 4 *donatista* (N), 2 *ecclesiasticus* (ADJ), 1 *euangelista* (N), 1 *expositor* (V), 1 *haereticus* (N), 2 *hypocrita* (N), 1 *idolum* (N), 1 *imperialis* (ADJ), 1 *increpatio* (N), 1 *mortifico* (V), 1 *nuditas* (N), 1 *parricidalis* (ADJ), 1 *peccator* (N), 2 *praedestinatio* (N), 1 *propheto* (V), 1 *propheticus* (ADJ), 1 *psalmus* (N), 1 *quadruplico* (V), 2 *recapitulatio* (N), 1 *regeneratio* (N), 1 *resurrectio* (N), 1 *reuelatio* (N), 1 *saluator* (V), 2 *sanctifico* (V), 8 *spiritualis* (ADJ), 1 *superuinco* (V), 1 *tribulatio* (N), 1 *uiuifico* (V)

1 Some of these words were certainly used before AD 200 (e.g. *apostolus* or *imperialis*) and the literary sources are simply lacking; some others are just Greek words imported into Latin (*charisma*, *epinicion*).

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<u>Donatus</u>: 3 *ablatio* (N), 2 *acyrologia* (N), 2 *anadiplosis* (N), 2 *anaphora* (N), 2 *antiphrasis* (N), 2 *antithesis* (N), 2 *aphaeresis* (N), 2 *apocope* (N), 2 *appellatiuus* (ADJ), 3 *appositio* (N), 3 *astismos* (N), 1 *asyndeton* (N), 1 *barbarolexis* (N), 1 *bipertitus* (ADJ), 2 *cacemphaton* (N), 3 *cacosyntheton* (N), 2 *causalis* (ADJ), 3 *conlisio* (V), 4 *comparatiuus* (ADJ), 2 *copulatiuus* (ADJ), 6 *defectiuus* (ADJ), 3 *diaeresis* (N), 2 *dialyton* (N), 2 *dianoea* (N), 1 *discissio* (V), 2 *disiunctiuus* (ADJ), 1 *dualis* (ADJ), 3 *ectasis* (N), 2 *ecthlipsis* (N), 3 *epenthesis* (N), 2 *epizeuxis* (N), 1 *euphonia* (N), 2 *expletiuus* (ADJ), 1 *extensio* (V), 2 *homoeoptoton* (N), 2 *homoeoteleuton* (N), 2 *hysterologia* (N), 2 *icon* (N), 1 *imperatiuus* (ADJ), 2 *indicatiuus* (ADJ), 1 *innoceo* (V),[2] 1 *inrisio* (N), 1 *iotacismus* (N), 1 *labdacismus* (N), 1 *longiusculus* (ADJ), 2 *macrologia* (N), 2 *metalempsis* (N), 3 *metaplasmus* (N), 2 *metathesis* (N), 2 *paradigma* (N), 3 *paragoge* (N), 2 *parenthesis* (N), 2 *paroemia* (N), 2 *paronomasia* (N), 2 *perissologia* (N), 2 *pleonasmus* (N), 3 *plusquamperfectum* (N), 2 *polyptoton* (N), 3 *prosthesis* (N), 2 *sarcasmos* (N), 2 *synaliphe* (N), 2 *synchysis* (N), 2 *syncopes* (N), 2 *systole* (N), 2 *tapinosis* (N), 2 *tautologia* (N), 1 *thymbre* (N), 2 *tmesis* (N), 1 *transformatio* (N), 1 *transnominatio* (N), 1 *uocaticus* (ADJ)

<u>Boethius 1</u>: 2 *constitutiuus* (ADJ), 2 *diuisibilis* (ADJ), 1 *inanimatus* (ADJ), 1 *insensibilis* (ADJ), 3 *inseparabilis* (ADJ), 3 *natabilis* (ADJ), 2 *reptilis* (ADJ), 30 *risibilis* (ADJ), 8 *separabilis* (ADJ), 1 *specificus* (ADJ), 2 *substantialis* (ADJ), 4 *uniuocus* (ADJ)

<u>Boethius 2</u>: 1 *alternatio* (N), 2 *constitutiuus* (ADJ), 1 *contrarietas* (N), 1 *disgrego* (V), 1 *inremissibilis* (ADJ), 2 *pluralitas* (N), 3 *praedicamentum* (N), 1 *quinarius* (ADJ), 19 *risibilis* (ADJ), 8 *separabilis* (ADJ), 1 *subintellego* (V), 1 *substantialis* (ADJ), 1 *susceptibilis* (ADJ)

<u>Isidore</u>: 1 *ablutio* (N), 1 *acrozymus* (N), 1 *anaglyphus* (N), 1 *antistichon* (N), 1 *apostolus* (N), 1 *arciuus* (ADJ), 1 *azymus* (N), 1 *bacillus* (N), 1 *basterna* (N), 1 *caloratus* (ADJ), 1 *cama* (N), 1 *canistrum* (N), 1 *capistrum* (N), 1 *capsus* (N), 2 *carenum* (N), 3 *carrum* (N), 1 *cauterium* (N), 1 *chama* (N), 1 *comestio* (N), 1 *confortor* (V), 1 *coquinarius* (ADJ), 1 *deauro* (V), 1 *deriuatiuus* (ADJ), 6 *deminutiuus* (ADJ), 1 *falcastrum* (N), 2 *frumen* (N), 1 *gabata* (N), 1 *gazophylacium* (N), 1 *gryphus* (N), 2 *haustrum* (N), 1 *hemicadium* (N), 1 *humectatio* (N), 1 *hydromel* (N), 1 *innouo* (V), 2 *isicium* (N), 1 *lucinus* (ADJ), 1 *melicratum* (N), 1 *mulgarium* (N), 1 *oenomelum* (N), 1 *plasmo* (V), 1 *postella* (N), 1 *psalmista* (N), 1 *quadrangulum* (N), 1 *sagma* (N), 2 *sagmarius* (ADJ), 1 *salma* (N), 2 *scutellum* (N), 1 *sedda* (N),[3] 2 *sicera* (N), 1 *singularitas* (N), 1 *superfluus* (ADJ), 1 *zema* (N)

<u>Bede</u>: 1 *annuatim* (ADV), 1 *apostata* (N), 7 *apostolus* (N), 3 *apostolicus* (ADJ), 1 *archangelus* (N), 1 *attamino* (V), 1 *attitulo* (V), 11 *azymus* (N), 1 *baptisma* (N), 1 *baptismus* (N), 2 *baptizo* (V), 3 *bissextus* (N), 3 *catholicus* (ADJ), 1 *charisma* (N), 1 *chronographus* (N), 1 *coepiscopus* (N), 1 *compendiosus* (ADJ), 1 *computus* (N), 1 *confessor* (V), 3 *cyclus* (N), 3 *dilectio* (N), 1 *dilucidatio* (N), 1 *dissonantia* (N), 1 *embolismus* (N), 2 *epinicion* (N), 2 *episcopus* (N), 1 *euangelicus* (ADJ), 2 *euangelista* (N), 1 *exterminator* (V), 1 *glorificus* (ADJ), 1 *glorifico* (V), 1 *haereticus* (N), 1 *homelia* (N), 4 *incarnatio* (N), 1 *inconuenienter* (ADV), 1 *incorruptibilis* (ADJ), 1 *litteralis* (ADJ), 1 *longimanus* (ADJ), 1 *manifestatio* (N), 4 *martyr* (N), 1 *martyrium* (N), 1 *ogdoas* (N), 17 *paschalis* (ADJ), 1 *perditio* (N), 1 *plenarius* (ADJ), 2 *propheto* (V), 2 *psalmus* (N), 1 *psalmista* (N), 1 *psalmographus* (N), 1 *regeneratio* (N), 1 *reprobus* (ADJ), 20 *resurrectio* (N), 13 *sabbatum* (N), 3 *saluator* (V), 1 *sanctifico* (V), 6 *solemnitas* (N), 1 *speculatiuus* (ADJ), 6 *spiritualis* (ADJ), 1 *supputatio* (N), 2 *synodus* (N), 1 *tenebresco* (V), 1 *typicus* (ADJ)

2 Although as a 'non-word': *ut nocens innocens: nam noceo dicitur, innoceo non dicitur* (*Ars maior* II.14, ed. Holtz, p. 646).

3 Another 'non-word': *Sella a sedendo, quasi sedda* (*Etymologiae* XX.11, ed. Lindsay).

Rabanus Maurus: 1 *adafflictio* (N), 1 *allegoricus* (ADJ), 1 *altare* (N), 1 *angelus* (N), 1 *anterior* (V), 1 *antistichon* (N), 5 *apostolus* (N), 2 *apostolicus* (ADJ), 1 *approximo* (V), 1 *azymus* (N), 2 *baptisma* (N), 1 *baptista* (N), 2 *cama* (N), 2 *camus* (N), 3 *canistrum* (N), 1 *carnalis* (ADJ), 2 *carrum* (N), 1 *cauterium* (N), 2 *charitas* (N), 4 *compunctio* (N), 1 *confrixo* (V), 1 *contemplatiuus* (ADJ), 1 *cooperatio* (N), 3 *deceptio* (N), 1 *deriuatiuus* (ADJ), 1 *diabolicus* (ADJ), 2 *deminutiuus* (ADJ), 1 *elucesco* (V), 1 *emundatio* (N), 4 *euangelicus* (ADJ), 1 *falcastrum* (N), 2 *gazophylacium* (N), 5 *haereticus* (N), 2 *haustrum* (N), 1 *incarnatio* (N), 1 *inexstinguibilis* (ADJ), 1 *inspiratio* (N), 1 *instabilitas* (N), 1 *legisperitus* (ADJ), 1 *lucinus* (ADJ), 1 *molendinum* (N), 1 *paralyticus* (ADJ), 1 *patriarcha* (N), 3 *peccator* (N), 1 *peccatrix* (N), 2 *permundo* (V), 1 *possibilitas* (N), 1 *propheticus* (ADJ), 13 *psalmus* (N), 2 *psalmista* (N), 1 *puritas* (N), 1 *rectitudo* (V), 1 *retributio* (N), 1 *sagma* (N), 2 *sagmarius* (ADJ), 3 *saluator* (N), 1 *sanctifico* (V), 1 *sauma* (N), 2 *scandalizo* (V), 1 *scriniarius* (ADJ), 1 *sitarcia* (N), 4 *spiritalis* (ADJ), 1 *stigo* (V), 1 *succisio* (V), 1 *sufferentia* (N), 1 *superfluus* (ADJ), 1 *superincumbo* (V), 1 *thesaurizatio* (N), 5 *tribulatio* (N), 1 *trinitas* (N), 1 *tropologia* (N)

John Scotus Eriugena: 4 *aduno* (V), 1 *adunatio* (N), 10 *angelus* (N), 3 *apostolus* (N), 1 *appetitor* (N), 1 *appetitrix* (N), 1 *archangelus* (N), 2 *carnalis* (ADJ), 4 *catholicus* (ADJ), 1 *compatior* (V), 1 *concateno* (V), 1 *condescensio* (V), 1 *condignus* (ADJ), 1 *cooperator* (V), 9 *creatura* (N), 6 *deificatio* (N), 2 *diabolicus* (ADJ), 1 *dormitatio* (N), 1 *euangelicus* (ADJ), 1 *euangelista* (N), 1 *eximietas* (N), 1 *expositiuncula* (N), 1 *fiducialis* (ADJ), 1 *generalitas* (N), 1 *glorifico* (V), 2 *inaccessibilis* (ADJ), 1 *incorruptibilis* (ADJ), 1 *inscrutabilis* (ADJ), 2 *intellectualis* (ADJ), 2 *intelligibilis* (ADJ), 1 *inuestigabilis* (ADJ), 2 *irrationabilis* (ADJ), 1 *iussio* (V), 1 *materialis* (ADJ), 3 *numerositas* (N), 3 *parabola* (N), 1 *paradigma* (N), 1 *possibilitas* (N), 2 *primordialis* (ADJ), 2 *propheto* (V), 2 *psalmus* (N), 2 *regeneratio* (N), 2 *resurrectio* (N), 1 *reuolutio* (N), 1 *rimo* (V), 3 *sabbatum* (N), 1 *saluator* (V), 1 *specialitas* (N), 1 *speculatio* (N), 9 *spiritualis* (ADJ), 3 *substantialis* (ADJ), 2 *superessentialis* (ADJ), 1 *superfluus* (ADJ), 1 *superfulgeo* (V), 6 *supernaturalis* (ADJ), 1 *surrectio* (N), 1 *tantillus* (ADJ), 1 *theologus* (N), 6 *theoria* (N), 1 *trinitas* (N), 1 *typicus* (ADJ), 2 *uiuifico* (V), 1 *unigenitus* (ADJ)

Anselm of Canterbury: 1 *coaeternus* (ADJ), 1 *essentialis* (ADJ), 2 *incongruus* (ADJ), 7 *increatus* (ADJ), 2 *nullatenus* (ADJ), 1 *omnipotentia* (N), 2 *pluralitas* (N), 1 *trinus* (ADJ)

Abelard: 15 *aequiuocus* (ADJ), 1 *aequiuocatio* (N), 21 *albedo* (N), 1 *assignatio* (N), 2 *certitudo* (V), 1 *consignifico* (V), 3 *constitutiuus* (ADJ), 1 *conuertibilis* (ADJ), 3 *diphthongus* (N), 8 *dubietas* (N), 1 *duplicitas* (N), 1 *imperfectio* (N), 2 *inanimatus* (ADJ), 1 *irrationabilis* (ADJ), 7 *latrabilis* (ADJ), 2 *multiplicitas* (N), 1 *obiectio* (N), 1 *perceptibilis* (ADJ), 3 *praedicamentum* (N), 2 *rationalitas* (N), 1 *restrictio* (N), 1 *submissio* (V), 11 *substantialis* (ADJ), 3 *substantiuus* (ADJ), 4 *superfluus* (ADJ), 3 *superfluitas* (N), 1 *suprapono* (V), 6 *uniuocus* (ADJ), 1 *uniuocatio* (N)

Guilelmus de Conchis: 1 *accidentalis* (ADJ), 1 *angelus* (N), 1 *assimilatiuus* (ADJ), 2 *augmento* (V), 2 *colera* (N), 2 *comestio* (N), 1 *commastico* (V), 2 *confortor* (V), 1 *contrarietas* (N), 3 *creatura* (N), 1 *definitio* (N), 1 *digestiuus* (ADJ), 2 *ebullitio* (N), 1 *effluxio* (V), 1 *formatiuus* (ADJ), 8 *frigiditas* (N), 6 *humiditas* (N), 1 *hypostasis* (N), 1 *idoneitas* (N), 1 *influxio* (V), 4 *logisticus* (ADJ), 1 *molendinarius* (ADJ), 2 *natiuitas* (N), 4 *obstaculum* (N), 2 *phantasticus* (ADJ), 1 *quadruuium* (N), 1 *restauratio* (N), 1 *sedimen* (N), 5 *sperma* (N), 1 *sphaericus* (ADJ), 3 *spiritualis* (ADJ), 1 *subintro* (V), 1 *subtilio* (V), 4 *superfluito* (V), 8 *superfluitas* (N), 1 *superfluus* (ADJ), 1 *susceptrix* (N), 1 *tuitio* (N), 7 *uisualis* (ADJ)

Hugh of St Victor: 1 *aeternaliter* (ADV), 8 *alteratio* (N), 2 *angelus* (N), 1 *apostolus* (N), 1 *celsitudo* (N), 11 *charitas* (N), 1 *circumquaque* (ADV), 1 *clarifico* (V), 2 *coaeternus* (ADJ), 27 *creatura* (N), 8 *deitas* (N), 1 *delectabilis* (ADJ), 1 *desiderabilis* (ADJ), 2 *dilectio* (N), 1 *essentialiter* (ADV), 2 *factor* (N), 1 *incommutabilis* (ADJ), 1 *inuariabilis* (ADJ), 2 *mediator* (N), 1 *omnipotentia* (N), 2 *praescientia* (N), 1 *propheta* (N), 1 *psalmista* (N), 1 *recompenso* (V), 2 *resurrectio* (N), 1 *sensifico* (V), 1 *substantialiter* (ADV), 1 *transpositio* (N), 4 *trinitas* (N), 1 *ullatenus* (ADJ), 7 *uisibilis* (ADJ), 4 *uiuifico* (V)

Albertus Magnus: 3 *accidentalis* (ADJ), 1 *aequiuocus* (ADJ), 2 *apostolus* (N), 1 *catholicus* (ADJ), 1 *causalitas* (N), 1 *compassio* (V), 1 *contrarietas* (N), 4 *corruptibilis* (ADJ), 7 *creatura* (N), 6 *diffinitio* (N), 1 *diuersifico* (V), 1 *diuisibilis* (ADJ), 1 *dogmatizo* (V), 1 *elongo* (V), 3 *entitas* (N), 5 *existentia* (N), 2 *haereticus* (N), 2 *immediatus* (ADJ), 1 *impartibilis* (ADJ), 1 *imperfectio* (N), 1 *impletio* (N), 2 *incorruptibilis* (ADJ), 4 *indiuisibilis* (ADJ), 1 *innouatio* (N), 1 *inquantum* (ADV), 1 *intellectualis* (ADJ), 1 *intelligibilis* (ADJ), 1 *intraneus* (ADJ), 1 *materialis* (ADJ), 1 *mensuro* (V), 3 *metaphysica* (N), 1 *meteorus* (ADJ), 3 *obiectio* (N), 1 *peccator* (N), 2 *planeta* (N), 1 *praehabito* (V), 1 *proportiono* (V), 1 *reprobo* (V), 1 *resurrectio* (N), 3 *scibilis* (ADJ), 1 *sotularis* (ADJ), 2 *substantialis* (ADJ), 1 *theologia* (N), 1 *totalis* (ADJ), 1 *uegetabilis* (ADJ), 1 *uniuocus* (ADJ)

Thomas Aquinas: 7 *accidentalis* (ADJ), 2 *aequiuocus* (ADJ), 1 *anathema* (N), 1 *angelus* (N), 21 *apostolus* (N), 1 *concupiscibilis* (ADJ), 1 *consubstantialis* (ADJ), 3 *creatura* (N), 2 *essentialis* (ADJ), 1 *euangelista* (N), 1 *falsitas* (N), 28 *hypostasis* (N), 1 *immaterialis* (ADJ), 1 *impassibilis* (ADJ), 5 *incarnatio* (N), 1 *incarno* (V), 1 *infallibilis* (ADJ), 9 *inhabitatio* (N), 1 *inquantum* (N), 1 *intellectualis* (ADJ), 1 *irascibilis* (ADJ), 1 *metaphoricus* (ADJ), 1 *miscibilis* (ADJ), 1 *palpabilis* (ADJ), 1 *participabilis* (ADJ), 1 *personalitas* (N), 3 *phantasticus* (ADJ), 1 *potentialis* (ADJ), 1 *praedicamentum* (N), 2 *primogenitus* (ADJ), 1 *psalmus* (N), 2 *sanctifico* (V), 1 *sensitiuus* (ADJ), 1 *specificus* (ADJ), 2 *subsistentia* (N), 1 *substantialis* (ADJ), 1 *subtractio* (N), 1 *supernaturalis* (ADJ), 1 *synodalis* (ADJ), 4 *synodus* (N), 1 *uirtuosus* (ADJ), 1 *uiuifico* (V), 1 *unibilis* (ADJ)

Roger Bacon: 7 *affectuosus* (ADJ), 1 *angelus* (N), 4 *apostolus* (N), 1 *beneplacitus* (ADJ), 1 *calcaneus* (ADJ), 1 *catholicus* (ADJ), 2 *certifico* (V), 1 *compassio* (V), 2 *compatior* (V), 1 *condescendo* (V), 1 *conformis* (ADJ), 1 *conpatior* (V), 1 *contrarior* (V), 1 *creatura* (N), 1 *deifico* (V), 1 *deitas* (N), 4 *delectabilis* (ADJ), 1 *diabolicus* (ADJ), 3 *ecclesiasticus* (ADJ), 1 *extensio* (V), 1 *falsitas* (N), 1 *glorifico* (V), 1 *grandisonus* (ADJ), 1 *identitas* (N), 1 *illuminatio* (N), 2 *inductiuus* (ADJ), 1 *insensibilis* (ADJ), 2 *iustifico* (V), 1 *natiuitas* (N), 3 *operabilis* (ADJ), 2 *peccator* (N), 2 *perplexitas* (N), 1 *praedestino* (V), 1 *propheticus* (ADJ), 16 *speculatiuus* (ADJ), 1 *spiritualis* (ADJ), 1 *uentositas* (N), 1 *unigenitus* (ADJ)

Lullus: 1 *abstractio* (N), 2 *accidentalis* (ADJ), 2 *affirmatiuus* (ADJ), 1 *agibilis* (ADJ), 3 *albedo* (V), 2 *alphabetum* (N), 1 *alteratio* (N), 10 *angelus* (N), 3 *angelicus* (ADJ), 3 *applicabilis* (ADJ), 2 *approprio* (V), 2 *calefactio* (N), 2 *capa* (N), 1 *circulatio* (N), 1 *concateno* (V), 2 *contrarietas* (N), 1 *cordetenus* (ADJ), 1 *deceptio* (N), 1 *dediuersimodus* (ADJ), 1 *effectiuus* (ADJ), 2 *existentia* (N), 1 *explicabilis* (ADJ), 5 *habituo* (V), 1 *imaginabilis* (ADJ), 3 *imaginatiuus* (ADJ), 1 *incarnatio* (N), 1 *inconuenienter* (ADV), 1 *indiuisibilis* (ADJ), 4 *infallibilis* (ADJ), 1 *infernalis* (ADJ), 1 *intitulo* (V), 4 *maioritas* (N), 1 *martellus* (N), 1 *materialis* (ADJ), 5 *minoritas* (N), 2 *modalitas* (N), 1 *monasterium* (N), 1 *naturabilis* (ADJ), 2 *naturo* (V), 1 *obiectiuus* (ADJ), 1 *otiositas* (N), 1 *passibilis* (ADJ), 1 *risibilis* (ADJ), 6 *scholaris* (ADJ), 4 *sensitiuus* (ADJ), 2 *sensualis* (ADJ), 1 *specificus* (ADJ), 1 *subdiuido* (V), 5 *substantialis* (ADJ), 3 *theoricus* (ADJ)

Duns Scotus: 2 *abstractio* (N), 1 *absurditas* (N), 1 *affirmatiuus* (ADJ), 1 *albedo* (V), 2 *angelus* (N), 1 *annihilo* (V), 2 *approximo* (V), 2 *completiuus* (ADJ), 1 *constitutiuus* (ADJ), 6 *contingenter* (ADV), 4 *contrarietas* (N), 2 *coordinatio* (N), 1 *copulatiuus* (ADJ), 4 *corruptibilis* (ADJ), 1 *diuersifico* (V), 1 *diuisim* (ADV), 3 *entitas* (N), 1 *essentialis* (ADJ), 2 *existentia* (N), 1 *falsitas* (N), 1 *hypothesis* (N), 2 *identitas* (N), 1 *immediatus* (ADJ), 1 *impedibilis* (ADJ), 3 *incorruptibilis* (ADJ), 1 *indiuidualis* (ADJ), 3 *in-*

diuiduatio (N), 1 *intellectualis* (ADJ), 1 *intelligibilis* (ADJ), 5 *intermedius* (ADJ), 1 *materialis* (ADJ), 13 *metaphysica* (N), 6 *numeralis* (ADJ), 1 *oppositio* (N), 2 *potentialis* (ADJ), 4 *praedestino* (V), 1 *praeintelligo* (V), 1 *prioritas* (N), 1 *proportiono* (V), 1 *proportionatus* (ADJ), 1 *quiditas* (N), 16 *realis* (ADJ), 3 *scibilis* (ADJ), 1 *sensatus* (ADJ), 2 *separabilis* (ADJ), 2 *singularitas* (N), 4 *specificus* (ADJ), 1 *substantialis* (ADJ), 1 *superfluus* (ADJ), 1 *trinitas* (N), 1 *uerifico* (V), 2 *uirtualis* (ADJ), 1 *uniuocus* (ADJ)

<u>Ockham</u>: 1 *accidentalis* (ADJ), 4 *aduerbialis* (ADJ), 4 *aequiualeo* (V), 2 *aequiuocatio* (N), 6 *aequiuocus* (ADJ), 13 *affirmatiuus* (ADJ), 2 *animalitas* (N), 4 *categoricus* (ADJ), 2 *causalis* (ADJ), 2 *communicabilis* (ADJ), 1 *condicionalis* (ADJ), 4 *constitutiuus* (ADJ), 3 *contingenter* (ADV), 2 *copulatiuus* (ADJ), 4 *creatura* (N), 3 *disgrego* (V), 1 *exclusiuus* (ADJ), 2 *falsitas* (N), 1 *identitas* (N), 3 *indirectus* (ADJ), 4 *indiuidualis* (ADJ), 1 *indiuisibilis* (ADJ), 11 *intellectiuus* (ADJ), 2 *latrabilis* (ADJ), 1 *mediatus* (ADJ), 2 *modernus* (ADJ), 3 *paternitas* (N), 1 *praenomino* (V), 2 *proportionalis* (ADJ), 13 *realis* (ADJ), 2 *risibilis* (ADJ), 6 *sensitiuus* (ADJ), 1 *singularius* (ADJ), 4 *specificus* (ADJ), 2 *substantialis* (ADJ), 1 *synonymum* (N), 1 *uerifico* (V)

<u>Copernicus</u>: 1 *additio* (N), 4 *aequilatus* (ADJ), 1 *diuisim* (ADV), 3 *hypothesis* (ADJ), 1 *identitas* (N), 2 *orthogonium* (N), 1 *parallelus* (ADJ), 2 *particularis* (ADJ), 2 *porisma* (N), 1 *praestructio* (N), 1 *proportionabiliter* (ADV), 3 *proportionalis* (ADJ), 3 *rectilineus* (ADJ), 5 *segmentum* (N), 1 *sigillatim* (ADV), 11 *sphaericus* (ADJ), 29 *subtendo* (V), 6 *theorema* (N)

<u>Cardanus</u>: 1 *alternatim* (ADV), 1 *apogeus* (ADJ), 1 *aqueus* (ADJ), 1 *attractio* (N), 1 *bisextilis* (ADJ), 1 *circundo* (V), 1 *contrarietas* (N), 1 *correspondeo* (V), 1 *deectasis* (N), 1 *ephemeris* (ADJ), 1 *innotesco* (V), 4 *quartanus* (ADJ), 1 *quotidianus* (ADJ), 1 *turgeo* (V)

<u>Vesalius</u>: 1 *anatomicus* (ADJ), 3 *anterior* (N), 3 *arcualis* (ADJ), 1 *cartilagineus* (ADJ), 1 *catenula* (N), 3 *correspondeo* (V), 3 *cuneiformis* (ADJ), 1 *delineatio* (N), 1 *dualis* (ADJ), 2 *efformo* (V), 1 *emundatio* (N), 1 *fenestrum* (N), 1 *insertio* (N), 3 *intrudo* (V), 2 *lumbare* (N), 1 *maiusculus* (ADJ), 1 *mamillaris* (ADJ), 1 *mandibulum* (N), 1 *orbicularis* (ADJ), 2 *parietalis* (ADJ), 1 *praescindo* (V), 1 *reptilis* (ADJ), 2 *risorius* (ADJ), 7 *seriatim* (ADV), 4 *sesaminus* (ADJ), 1 *subiugalis* (ADJ)

<u>Suárez</u>: 1 *abstractio* (N), 4 *accidentalis* (ADJ), 1 *actualis* (ADJ), 1 *adaequatus* (ADJ), 1 *aequiualeo* (V), 1 *albedo* (V), 6 *angelus* (N), 5 *aptitudo* (V), 1 *concomitantia* (N), 2 *connaturalis* (ADJ), 1 *constitutiuus* (ADJ), 1 *contingens* (ADJ), 6 *contradictorius* (ADJ), 1 *contrarietas* (N), 1 *correspondeo* (V), 1 *creatura* (N), 1 *emanatio* (N), 2 *entitas* (N), 9 *essentialis* (ADJ), 2 *existentia* (N), 1 *filiatio* (N), 2 *fundamentalis* (ADJ), 2 *identitas* (N), 1 *illatio* (N), 1 *immaterialis* (ADJ), 1 *immediatus* (ADJ), 1 *incapacitas* (N), 1 *inexistens* (ADJ), 2 *intellectio* (N), 3 *materialis* (ADJ), 2 *obiectio* (N), 2 *oppositio* (N), 1 *partialis* (ADJ), 5 *praedicamentum* (N), 1 *prioritas* (N), 5 *proportionalis* (ADJ), 47 *realis* (ADJ), 1 *scibilis* (ADJ), 1 *separabilis* (ADJ), 1 *specifico* (V), 2 *subdistinguo* (V), 1 *subdiuisio* (V), 2 *substantialis* (ADJ), 1 *totalis* (ADJ), 2 *uirtualis* (ADJ)

<u>Galileo</u>: 1 *aequilaterum* (N), 1 *astronomus* (ADJ), 1 *attenuatio* (N), 1 *attestatio* (N), 5 *configuratio* (N), 1 *constellatio* (N), 1 *contorno* (V), 1 *conuertibilis* (ADJ), 1 *coordinata* (N), 2 *coordinatio* (N), 1 *delineatio* (N), 1 *elongatio* (N), 7 *elongo* (V), 1 *horarius* (ADJ), 4 *illuminatio* (N), 2 *intermedius* (ADJ), 8 *interstitium* (N), 1 *irradiatio* (N), 1 *irradio* (V), 1 *lunula* (N), 1 *multiplicitas* (N), 1 *obtenebro* (V), 1 *orbicularis* (ADJ), 1 *peripheria* (N), 1 *perpendiculariter* (ADV), 12 *perspicillum* (N), 23 *planeta* (N), 1 *reuolutio* (N), 14 *stellula* (N),

Vossius: 1 *angelus* (N), 1 *archiuum* (N), 2 *diaconus* (N), 1 *monachus* (N), 1 *monasterium* (N), 1 *rhetoricor* (V), 3 *martyr* (N)

Descartes: 1 *aspectabilis* (ADJ), 1 *astronomus* (N), 2 *borealis* (ADJ), 1 *catenula* (N), 1 *catholicus* (ADJ), 1 *circumquaque* (ADV), 1 *cognoscibilis* (ADJ), 1 *collisio* (V), 1 *correspondeo* (V), 2 *diuersimodus* (ADJ), 1 *diuisibilis* (ADJ), 4 *efformo* (V), 1 *fruitio* (N), 4 *humiditas* (N), 2 *immediatus* (ADJ), 1 *indiuisibilis* (ADJ), 1 *insensibilis* (ADJ), 1 *intellectualis* (ADJ), 3 *interstitium* (N), 2 *magneticus* (ADJ), 4 *materialis* (ADJ), 1 *metaphysicus* (ADJ), 1 *meteorus* (ADJ), 4 *neruulum* (N), 1 *quotidianus* (ADJ), 1 *realis* (ADJ), 5 *rimula* (N), 2 *sensilis* (ADJ), 1 *speciatim* (ADV), 1 *sphaericus* (ADJ), 2 *substantialis* (ADJ), 1 *tristor* (V)

Spinoza: 1 *actualis* (ADJ), 2 *adaequatus* (ADJ), 3 *animositas* (N), 3 *concateno* (V), 4 *concomitor* (V), 3 *dictamen* (N), 3 *existentia* (N), 1 *gratitudo* (V), 1 *indirectus* (ADJ), 1 *ingratitudo* (V), 8 *intellectualis* (ADJ), 1 *inuoluntarius* (ADJ), 1 *melancholia* (N), 1 *pusillanimitas* (N)

Kircher: 1 *abominatio* (N), 2 *absurditas* (N), 1 *anatomia* (N), 2 *aqueus* (ADJ), 1 *assidentia* (N), 1 *brutalis* (ADJ), 1 *calcaneum* (N), 2 *campanula* (N), 1 *capitaneus* (ADJ), 2 *coenobium* (N), 1 *cognoscitiuus* (ADJ), 1 *computresco* (V), 1 *daemonicus* (ADJ), 2 *demento* (V), 1 *depraedico* (V), 1 *destructor* (N), 1 *diabolicus* (ADJ), 1 *eleemosynarius* (ADJ), 1 *euangelicus* (ADJ), 1 *euanescentia* (N), 1 *exstasis* (ADJ), 1 *exstaticus* (ADJ), 1 *fortalitium* (N), 1 *genealogia* (N), 1 *gesticulatio* (N), 1 *gratitudo* (N), 1 *hypocrisis* (N), 3 *idolum* (N), 2 *idololatria* (N), 1 *impostor* (N), 4 *incarno* (V), 5 *incarnatio* (N), 2 *infallibilis* (ADJ), 1 *insufficiens* (ADJ), 1 *intellectualis* (ADJ), 1 *irascibilis* (ADJ), 1 *itinerarium* (N), 1 *materialis* (ADJ), 1 *metempsychosis* (ADJ), 1 *misericorditer* (ADV), 1 *modernus* (ADJ), 1 *monasterium* (N), 2 *monstruosus* (ADJ), 1 *mundanus* (ADJ), 1 *natabilis* (ADJ), 2 *particularis* (ADJ), 1 *perbeatus* (ADJ), 1 *phanaticus* (ADJ), 2 *phantasticus* (ADJ), 1 *realiter* (ADV), 1 *relido* (V), 1 *retractio* (N), 3 *satanicus* (ADJ), 1 *specificus* (ADJ), 1 *spontaneus* (ADJ), 1 *superuestitus* (ADJ), 1 *theologia* (N), 2 *transmigratio* (N), 4 *transmuto* (V), 2 *trinitas* (N), 1 *ullatenus* (ADJ), 1 *uegetabilis* (ADJ)

Newton: 2 *arithmetica* (N), 13 *atmosphaera* (N), 5 *borealis* (ADJ), 1 *calefactio* (N), 24 *cometa* (N), 1 *curuilineus* (ADJ), 1 *cylindricus* (ADJ), 1 *decuplus* (ADJ), 1 *deflexio* (V), 6 *deuiatio* (N), 3 *ecliptica* (N), 1 *excentricus* (ADJ), 2 *grauito* (V), 1 *hypothesis* (N), 2 *indies* (N), 1 *micrometrum* (N), 1 *monachus* (N), 4 *oppositio* (N), 2 *opticus* (ADJ), 3 *parabolicus* (ADJ), 3 *parallelus* (ADJ), 2 *periodicus* (ADJ), 1 *perpendicularis* (ADJ), 10 *planeta* (N), 2 *putrefactio* (N), 2 *rarefactio* (N), 9 *refractio* (N), 1 *reuolutio* (N), 2 *scintillatio* (N), 4 *semidiameter* (N), 2 *specificus* (ADJ), 1 *subobscurus* (ADJ), 4 *telescopium* (N), 15 *traiectoria* (N), 2 *uegetabilis* (ADJ)

Kretschmann: 2 *adiectiuus* (ADJ), 2 *allusio* (V), 1 *commodatio* (N), 1 *commorsito* (V), 1 *cumulatio* (N), 1 *deuinctio* (N), 1 *enallage* (N), 1 *gerundium* (N), 1 *idiotismus* (N), 1 *luxatio* (N), 3 *oppositio* (N), 1 *oxymorus* (N), 1 *paronomasia* (N), 1 *pellicatus* (ADJ), 1 *phraseologia* (N), 1 *seorsim* (ADV), 1 *singularitas* (N), 3 *substantiuus* (ADJ), 1 *taediosus* (ADJ), 1 *uelito* (V), 2 *uelitas* (N)

Boyer: 1 *abstractio* (N), 1 *actualis* (ADJ), 1 *adaequatio* (N), 1 *aequiuocatio* (N), 1 *agnosticismus* (N), 1 *alteratio* (N), 2 *appropriatio* (N), 1 *aptitudo* (V), 1 *atheismus* (N), 3 *atomismus* (N), 1 *bibliographia* (N), 1 *categoricus* (ADJ), 1 *causalitas* (N), 5 *certitudo* (V), 1 *clericus* (ADJ), 1 *cogitatiuus* (ADJ), 1 *communismus* (N), 2 *compenetratio* (N), 1 *concupiscibilis* (ADJ), 1 *condensatio* (N), 3 *cosmologia* (N), 6 *creatura* (N), 5 *criterium* (N), 1 *deductiuus* (ADJ), 1 *descriptiuus* (ADJ), 1 *determinismus* (N), 1 *dictamen* (N), 1 *eductio* (N), 1 *empirismus* (N), 1 *essentialis* (ADJ), 1 *euideo* (V), 1 *euthanasia* (N), 20 *existentia* (N), 5 *extensio* (V), 1 *falsitas* (N), 2 *finalitas* (N), 1 *generatiuus* (ADJ), 1 *hedonismus* (N), 1 *homogeneitas* (N), 2 *hypnosis* (N), 1 *hypothesis* (N), 6 *idealismus* (N), 3 *idealista* (N), 3 *illuminatio* (N), 1 *immaneo* (V), 1 *immaterialis* (ADJ), 2 *immaterialitas* (N), 1 *immediatus* (ADJ), 1 *immensitas* (N), 1 *immutabilitas* (N), 1 *imperatiuus* (ADJ), 1 *indiuidualis* (ADJ), 5 *indiuiduatio* (N), 4 *indiuisibilis* (ADJ), 1 *insensatus* (ADJ), 8 *intellectiuus* (ADJ), 2 *intelligibilis* (ADJ), 1 *irascibilis* (ADJ), 2 *legitimitas* (N), 1 *logisticus* (ADJ), 1 *materialis* (ADJ), 3 *mathesis* (N), 1 *mechanismus* (N), 2 *mentalis* (ADJ), 7 *metaphysica* (N), 2 *metaphysicus* (ADJ), 1 *methodicus* (ADJ), 1 *monarchia* (N), 9 *moralitas* (N), 1 *mutilatio* (N), 2 *nominalis* (ADJ), 1 *nutritiuus* (ADJ), 1 *obiectio* (N), 2 *omnipotentia* (N), 1 *ontologia* (N), 1 *oppositio* (N), 1 *palaeontologia* (N), 1 *pantheismus* (N), 1 *parallelismus* (N), 2 *personalitas* (N), 5 *phantasma* (N), 1 *polytheismus* (N), 3 *praedicamentum* (N), 2 *psychologia* (N), 1 *quiditas* (N), 1 *radioactiuitas* (N), 1 *rarefactio* (N), 10 *realis* (ADJ), 4 *realismus* (N), 2 *realitas* (N), 2 *reincarnatio* (N), 2 *reproductio* (N), 2 *restrictio* (N), 1 *scepticismus* (N), 2 *sensatio* (N), 5 *sensitiuus* (ADJ), 2 *socialismus* (N), 2 *spiritualis* (ADJ), 1 *spiritualitas* (N), 1 *spontaneus* (ADJ), 5 *substantialis* (ADJ), 1 *suicidium* (N), 1 *syllogisticus* (ADJ), 1 *synderesis* (N), 1 *systema* (N), 1 *telepathia* (N), 4 *theologia* (N), 2 *theoria* (N), 1 *traditionalismus* (N), 3 *transcendentalis* (ADJ), 2 *transcendentia* (N), 8 *ualor* (N), 1 *uniuocus* (ADJ), 1 *uegetatiuus* (ADJ)

<u>Translations from Greek</u>

<u>Vulgate (NT)</u>: 3 *abominatio* (N), 1 *altare* (N), 2 *amarico* (V), 1 *amodo* (V), 37 *angelus* (N), 2 *apostolus* (N), 1 *beryllus* (N), 4 *blasphemo* (V), 4 *blasphemia* (N), 1 *botrus* (N), 1 *calcedonius* (ADJ), 1 *citharizo* (V), 2 *coinquinatus* (ADJ), 2 *daemonium* (N), 1 *deauro* (V), 2 *euangelizo* (V), 1 *fornicarius* (ADJ), 3 *fornicor* (V), 4 *fornicatio* (N), 1 *fornicator* (V), 1 *glorifico* (V), 1 *idolatra* (N), 1 *idolum* (N), 1 *iustificatio* (N), 1 *iustifico* (V), 1 *martyr* (N), 1 *odibilis* (ADJ), 2 *propheto* (V), 2 *prostitutio* (N), 2 *resurrectio* (N), 1 *sanctifico* (V), 1 *sapphirus* (N), 1 *spiritualis* (ADJ), 1 *thyinus* (ADJ), 1 *topazium* (N)

<u>*De interpretatione*</u>: 1 *accidenter* (ADV), 1 *analyticus* (ADJ), 1 *bipeda* (N), 3 *contradictorius* (ADJ), 20 *contrarietas* (N), 6 *falsitas* (N), 1 *interrogatiuus* (ADJ), 1 *praedicamentum* (N), 1 *significatiuus* (ADJ), 1 *speculatio* (N), 2 *uniuersalitas* (N), 1 *uniuersalitas* (N),

<u>*Liber de causis*</u>: 1 *accidentalis* (ADJ), 1 *approximo* (V), 1 *certitudo* (V), 3 *continuator* (N), 1 *corporeitas* (N), 3 *destructibilis* (ADJ), 4 *diuersifico* (V), 1 *diuisibilis* (ADJ), 4 *durabilitas* (N), 1 *essentialis* (ADJ), 3 *fixio* (V), 1 *indiuisibilis* (ADJ), 6 *influxio* (V), 26 *intellectibilis* (ADJ), 1 *materialis* (ADJ), 1 *mensuro* (V), 1 *multiplicitas* (N), 1 *receptibilis* (ADJ), 1 *rememoror* (V), 3 *spiritualis* (ADJ), 2 *substantialis* (ADJ), 1 *substantialitas* (N), 1 *tortuositas* (N), 1 *uerifico* (V), 2 *uniuersalitas* (N)

<u>Argyropoulos</u>: 8 *alteratio* (N), 1 *contradictorius* (ADJ), 1 *contrarietas* (N), 3 *corruptibilis* (ADJ), 4 *decretio* (N), 1 *disgrego* (V), 2 *diuisibilis* (ADJ), 1 *imperfectio* (N), 1 *incessabilis* (ADJ), 1 *incorruptibilis* (ADJ), 1 *indiuisibilis* (ADJ), 1 *infinities* (ADV), 1 *mensuro* (V), 1 *oppositio* (N), 2 *segregatio* (N)

<u>Ficinus</u>: 1 *alteritas* (N), 1 *aptitudo* (V), 1 *assignatio* (N), 1 *astronomus* (N), 2 *compassio* (V), 2 *compatior* (V), 1 *contemplabilis* (ADJ), 2 *contrarietas* (N), 1 *corruptibilis* (ADJ), 1 *daemonicus* (ADJ), 2 *daemonium* (N), 1 *deceptio* (N), 2 *deificus* (ADJ), 1 *immaterialis* (ADJ), 2 *impartibilis* (ADJ), 1 *inaestimabilis* (ADJ), 1 *indeterminatus* (ADJ), 2 *influxus* (N), 1 *innouo* (V), 1 *inspiratio* (N), 1 *instabilitas* (N), 12 *intellectualis* (ADJ), 14 *intelligibilis* (ADJ), 1 *magnipendo* (V), 1 *materialis* (ADJ), 1 *obfusco* (V), 1 *obsecrator* (V), 1 *opificio* (V), 1 *phantasticus* (ADJ), 2 *planeta* (N), 2 *praecognitio* (N), 1 *propheto* (V), 1 *seductor* (V), 4 *symbolicus* (ADJ), 1 *theologia* (N).

Appendix 2

See chapter 20 §3 above. A similar list to that in appendix 1, now for the arithmetic texts used in chapter 20. The table in chapter 20 §4 provides information on the authors and texts. As these works are much shorter, only 1,000 words between word 1,000 and 2,000 of each work were used (in contrast to those in appendix 1, which stem from a sample of 5,000 words). The list is, again, lemmatised and contains for each lemma its PoS and the number of occurrences in the sample.

Martianus Capella: 1 *apocatastaticus* (ADJ), 1 *arithmeticus* (ADJ), 3 *decas* (N), 3 *dipondius* (ADJ), 7 *dyas* (N), 1 *edisseco* (V), 4 *enneas* (N), 1 *hebdomas* (N), 3 *heptas* (N), 1 *hexas* (N), 1 *medilunium* (N), 2 *monas* (N), 4 *octas* (N), 1 *paritas* (N), 1 *pentas* (N), 1 *possibilitas* (N), 8 *trias* (N)

Boethius: 4 *astronomicus* (ADJ), 1 *denominatiuus* (ADJ), 1 *epitritus* (ADJ), 1 *epogdous* (ADJ), 1 *interminabilis* (ADJ), 1 *medietas* (N), 1 *pluralitas* (N), 1 *quadriuium* (N), 1 *sphaericus* (ADJ)

Isidore: 3 *linealis* (ADJ), 1 *millenarius* (ADJ), 3 *monas* (N), 1 *octonarius* (ADJ), 1 *quaternarius* (ADJ), 4 *quinarius* (ADJ), 2 *quinqueangulus* (ADJ), 6 *submultiplex* (ADJ), 4 *subsuperparticularis* (ADJ), 3 *subsuperpartiens* (ADJ), 1 *superficialis* (ADJ), 1 *superficiosus* (ADJ), 4 *superparticularis* (ADJ), 4 *superpartiens* (ADJ), 2 *superpartionalis* (ADJ), 2 *ternarius* (ADJ), 2 *trigonus* (ADJ), 3 *trinarius* (ADJ)

Ps-Bede: 1 *concupiscentia* (N), 1 *linteamen* (N), 4 *medietas* (N), 1 *plaustralis* (ADJ), 1 *superabundo* (V)

Anonymus Siculus: 14 *couterque* (PRON), 2 *porisma* (N)

Regule: 9 *aggregatio* (N), 1 *decuplo* (V), 2 *proportionalis* (ADJ), 1 *quaternarius* (ADJ)

Anxiomata: 4 *binarius* (ADJ), 1 *disciplinalius* (ADJ), 2 *medietas* (N), 2 *octonarius* (ADJ), 3 *proportionalis* (ADJ), 1 *proportiono* (V), 3 *quaternarius* (ADJ), 1 *quinarius* (ADJ), 8 *superpartiens* (ADJ), 7 *superparticularis* (ADJ), 1 *superparticularitas* (N), 5 *ternarius* (ADJ), 1 *trigesies* (ADJ), 1 *uigenarius* (ADJ), 3 *uigies* (ADJ)

Iordanus de Nemore: 5 *antepraemissus* (ADJ), 1 *indiuisus* (ADJ)

Iohannes de Muris: 9 *aliquotus* (ADJ), 2 *binarius* (ADJ), 1 *duplas* (N), 1 *submultiplex* (ADJ), 1 *subtractio* (N), 2 *superpartiens* (ADJ), 2 *superparticularis* (ADJ), 5 *ternarius* (ADJ), 4 *triplus* (ADJ)

Albert of Saxony: 28 *aliquotus* (ADJ), 1 *binarius* (ADJ), 2 *medietas* (N), 2 *proportionalis* (ADJ), 7 *proportio* (N), 5 *sesquialter* (PRON), 2 *sesquiquartus* (ADJ), 3 *sesquitertia* (PRON), 3 *submultiplex* (ADJ), 1 *subsuperpartiens* (ADJ), 1 *subsuperparticularis* (ADJ), 5 *superbipartiens* (ADJ), 14 *superpartiens* (ADJ), 7 *superparticularis* (ADJ), 1 *superquadripartiens* (ADJ), 3 *supertripartiens* (ADJ), 1 *ternarius* (ADJ)

Oresmius: 1 *algerismus* (ADJ), 6 *augmentatio* (N), 2 *improportionalis* (ADJ), 2 *incommensurabilis* (ADJ), 2 *intermedius* (ADJ), 1 *medietas* (N), 3 *proportionalis* (ADJ), 3 *quadruplus* (ADJ), 1 *quadruplico* (V), 9 *subduplus* (ADJ), 1 *suboctuplus* (ADJ), 5 *subquadruplus* (ADJ), 1 *subtractio* (N), 1 *subtriplus* (ADJ), 1 *superpositio* (N)

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Gamundia: 5 *aequidistans* (ADJ), 1 *algorithmus* (ADJ), 3 *parallellogrammum* (N), 4 *quadro* (V), 3 *rectangulum* (N), 1 *subtendo* (V), 6 *tetragonicus* (ADJ)

Maurolycus: 3 *aequiangulus* (ADJ), 3 *aequilaterus* (ADJ), 1 *bisquadratus* (ADJ), 27 *collateralis* (ADJ), 1 *dodecahedrum* (N), 4 *duodecuplus* (ADJ), 4 *heptagonus* (ADJ), 11 *hexagonus* (ADJ), 2 *icosahedrum* (N), 1 *imparitas* (N), 1 *monas* (N), 5 *octahedrum* (N), 2 *octogonus* (ADJ), 8 *pentagonus* (ADJ), 2 *prolegomena* (N), 1 *quadruplico* (V), 1 *quincuplico* (V), 1 *septangulum* (N), 1 *seriatim* (ADV), 3 *sexcuplus* (ADJ), 1 *speculativus* (ADJ), 1 *subtaceo* (V), 1 *superficialis* (ADJ), 2 *tetrahedrum* (N), 2 *trigecuplus* (ADJ), 2 *vigecuplus* (ADJ)

Vieta: 1 *adscititius* (ADJ), 1 *alphabeticus* (ADJ), 2 *analysta* (N), 1 *gradualis* (ADJ), 8 *heterogeneus* (ADJ), 3 *parodicus* (ADJ), 4 *permutatim* (ADV), 1 *proportionalis* (ADJ), 2 *subductio* (N), 3 *subgradualis* (ADJ), 3 *zeteticus* (ADJ)

Leibniz: 2 *aequatio* (N), 1 *aequiualeo* (V), 1 *algebraicus* (ADJ), 1 *algorithmus* (ADJ), 1 *binio* (N), 1 *catoptrica* (N), 3 *cycloeidis* (ADJ), 7 *differentialis* (ADJ), 2 *dioptrica* (N), 1 *homogeneus* (ADJ), 1 *imposterum* (N), 1 *indeterminatus* (ADJ), 1 *infinitangulum* (N), 1 *nominator* (N), 1 *particularis* (ADJ), 3 *rectangulum* (N), 3 *refractio* (N), 1 *separatrix* (ADJ), 1 *speciatim* (ADV), 1 *substituo* (V), 3 *ualor* (N)

Euler: 2 *affirmatiuus* (ADJ), 1 *criterium* (N), 1 *denominator* (N), 1 *diuisibilis* (ADJ), 1 *expressio* (N), 1 *factor* (N), 1 *fractio* (N), 3 *multiplus* (ADJ), 3 *negatiuus* (ADJ), 1 *particularis* (ADJ), 1 *substituo* (V), 3 *ualor* (N)

Gauss: 1 *additio* (N), 1 *combinatio* (N), 1 *criterium* (N), 1 *decadicus* (ADJ), 3 *diuiduus* (ADJ), 1 *diuisibilis* (ADJ), 1 *eleuatio* (N), 1 *factor* (N), 1 *multiplus* (ADJ), 4 *positiuus* (ADJ), 1 *praeliminarius* (ADJ), 1 *resolubilis* (ADJ), 1 *subtractio* (N), 1 *superfluus* (ADJ), 4 *systema* (N), 4 *theorema* (N), 1 *uerificatio* (N).

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There are four bibliographies. The first lists lexicons and encyclopaedias, which are cited in short form in the text. The second lists software. The third lists Latin and Greek primary texts; all texts fully written in Latin or Ancient Greek, including recent ones, are to be found here and are cited by author (anglicised where appropriate) and/or title in the text. The fourth list contains all other literature, which is quoted using the author-date system or (in the case of a small number of primary sources) by author and/or title. Occasionally, stable-looking Internet links are provided; they are freely accessible unless otherwise stated.

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